THE ART OF GVNNERY.

VV herein is set forth a number of seruiceable secrets, and practicall conclusions, belonging to the Art of Gunnerie, by Arithmeticke skill to be accomplished: both pretie, pleasant, and profitable for all such as are professors of the same facultie.

Compiled by THOMAS SMITH of *Barwicke* vpon Tweed Soldier.

LONDON.
Printed for WILLIAM PONSONBY. 1600.

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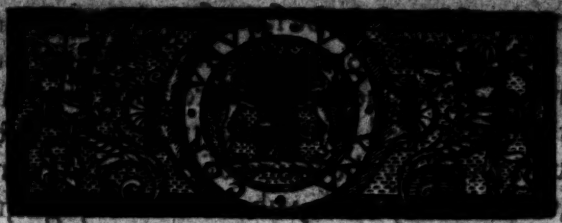


TO

THE RIGHT HONOVRABLE PERIGRIN BERTIE KNIGHT, Lord Willoughbie Beake and Earsby, Lord Gouernour of her Maiesties Towne and Castle of *Barwicke* vpon Tweed, and Lord Warden of the East marshes of *England*, for and except *Scotland*, &c.

IT is a common opinion, Right honourable, amongst a great number, who may be tearmed more wayward than wise, that the Art of Souldiery may perfectly be attained in two or three moneths practice, and that any common man in a few weekes trayning, hauing seen two or three skirmishes may be called an expert souldier. Not considering that a Mariner may saile seuen yeares, and yet be farre from a Nauigator. A number of Mechanicall Artificers may labour

diuers yeares and yet be farre from perfection; and a number of Souldiers may serue many yeares, and yet haue but the bare name of a Souldier. He may well be called a trained Souldier, that knoweth by the sound of Drum, & Trumpet, without any voice, when to march, fight, retire, &c. that is able in marching, embattelling, encamping, and fighting, and such like, to performe, execute, and obey the lawes and orders of the field; that hath some sight in the Mathematicals, and in Geometricall instruments, for the conueying of Mines vnder the ground, to plant and manage great Ordinance, to batter or beat down the wals of any Town or Castle, that can measure Altitudes, Latitudes, and Longitudes, &c. such a one may be termed, in my opinion, an expert Souldier, though hee neuer buckled with the enemie in the field.

Such perfections is well knowne to be in your Honour, that you are furnished with these and many more rare qualities in the Art Militarie, and aboue all with wisedome and noble courage, to performe and execute any honourable enterprise whatsoeuer for the honour and seruice of God, your Prince and Countrie, the which our proud enemies haue felt to their paine and your euerlasting fame.

And although I my ſelfe bee but one of the meaneſt ſouldiers in this Garriſon now vnder your Lordſhips gouernment (whom we pray long to gouern ouer vs) being brought vp from my childhood vnder a valiant Captaine in Militarie profeſſion, in which I haue had a deſire to practiſe and learne ſome ſecrets touching the orders of the field, and trayning of Souldiers: as alſo concerning the Art of Managing and ſhooting in great Artillerie. I haue thought it good (hearing of no other that hath done the like before) to frame together certaine Arithmeticall and Geometricall rules, to ſhew in part how neceſſarie Arithmeticke and Geometrie is for our profeſſion, the which I haue ſet down in two litle bookes: the one intituled Arithmeticall Militarie Concluſions, the other, The Art of Gunnery: the firſt I wrote two or three yeares ſince, and beſtowed on my Captaine, Sir *Iohn Carie* Knight, the which (God ſparing life) I meane to correct and enlarge, and perhaps put to the Preſſe: This other I haue thought it my part, to offer to your Lordſhips good conſideration, to be ſhrouded vnder your Honourable buckler, to beare off the blowes of enuious tongues, which are euer ready to ſpit their ſpite againſt any vertuous exerciſe: which although it bee

vnworthie to passe vnder so honourable a protection, I hope your Lordship will in indifferent ballance weigh my willing minde, to doe my Countrie good, and your Honour any seruice my poore abilitie is able to performe, which if your Honour allow of, I shall thinke my paines well employed, and shall encourage me hereafter to bring this new found Art into some better perfection, so farre as my poore abilitie is able to put in practice, or my simple skill in the Art will reach to. Thus loth to bee tedious, I cease: beseeching God to preserue your Honour with much increase of honour, to Gods glorie and your hearts desire.

Your honours dutifully at commaund,

THOMAS SMITH Souldier.

To all Gentlemen, Souldiers, Gunners, and all fauourers of Militarie Discipline,

THOMAS SMITH wisheth increase of happinesse.

GENTLEMEN, there was neuer Author nor practised Gunner euer able (as I am perswaded) to describe at full, or could shew perfectly the efficacie and force that Gunpowder is able to accomplish, it being a mixture of such a wonderfull operation and effect, as by daily experience wee finde. And although diuers men in diuers ages, haue inuented diuers Engines and Ordinance for offensiue and defensiue seruices by Gunpowder to bee performed, yet none hath, nor could euer attaine to that full perfection, to know precisely what strange effects the said mixture is able to worke. Also diuers learned men haue inuented many excellent rules pertaining to the Art of Gunnerie, and a great many of them haue and doe erre in the principalls of their inuentions: and the cause is, for want of due practice therein. For the Art of Gunnery doth require great practice and experience, to declare the rare secrets thereof, which is not for meane men to attaine to, for that the charge is great.

And albeit, I am the least able of a great many to take any matter in hand, pertaining to the same Art, being but a seruile scholler thereto, and my ability is far vnable to put in practise that I would: yet because I haue serued a prentiseehood twice told since I tooke my oath, and neuer hearing of any that hath compiled any Arithmeticall rules in figures (which is the fountaine head from whence all Arts or sciences doe spring) into one volume, I thought it my part and duty (according to my skill) to doe the best I could therein, for the

benefit

benefit of others, and that in the plainest maner I could, that such as are not well seene in numbers Art, might the sooner vnderstand the same. And albeit I haue herein shewed but a few Arithmeticall conclusions belonging to the Art of Gunnerie, yet the experienced Gunner or skilfull Mathematitian, by these few may deuise a great many moe, for seruice offensiue and defensiue, by Arithmeticke and Geometrie to be performed. All which conclusions (gentle Readers) I haue thought best to frame in easie questions, shewing the answers or resolution thereof. And although they be but meanly frawed, I hope you will accept the same in good part, the rather, for that they are a young Gunners practices. And if there be ought herein that may profit you, yeeld me your friendly censure, I craue no more: or if in any place I haue erred, either gently correct it, or passe it with silence, or in friendly sort admonish me thereof, I deserue no lesse.

There is a great many that can spie a mote in another mans eye, that had need to haue a beame pulled from their owne: some will scan very curiously, and sooner find two faults than amend one. If you be of that minde (friendly readers) I minde not to make you my iudges.

The widowes mite was aswell accepted as the gifts of the wealthy. A souldier in Alexanders campe, in the dry desert presented the King his helmet full of cold water, saying, If I could haue gotten better drinke, your Grace should haue had part: the which the King gently accepted and liberally rewarded, answering, I wey not the gift, but thy willing minde. But I seeke no reward for my trauell, but onely you will weigh my minde is willing to do my Countrey good, and to profit the readers: and not to carpe with Momus, nor disdaine with Zoilus, nor sooth with Zantippus. In so doing you shall encourage me to set penne to paper, and to flie a higher pitch

pertaining

pertaining to this new found Art. Otherwiſe, if you ſpit out your ſpite againſt me for my good will, I will as meanely account of your malice, and ſo as I finde you, looke to haue of mee. From my poore houſe in Barwicke vpon Tweed this 2. of May, 1600.

Your friend and wel-willer,

Thomas Smith Souldier.

PETER LVCAS CANNONNIER in commendation of the Author and his booke.

SHake ſilly pen to write of art, to him where art doth dwel,
And ſay, the want of Eloquence doth ſo thy hand repell,
That farre thy Muſe vnable is to praiſe the Authors skill:
Nor canſt thou paint thy minde, nor finely tell thy will.
But as there needs no ſigne at dore, where as the wine is pure,
So need not I commend this worke, it all men will allure,
To loue the Smith that forg'd this worke, who hath ſuch Art in ſtore,
That better is than Art which trieth gold from ore,
As our proud foes haue found, and felt by Ordinance might,
And ayde of the almighty Ioue, who doth defend our right.
Therefore good Zeale go poſt-haſt vnto fame,
And bid her giue this booke an euer-liuing name.

PERER LVCAS Gunner.

RICHARD

RICHARD HOPE Gentleman in commendation of the worke.

TO tell a tale without authoritie,
Or faine a fable by inuention,
The one proceeds of quicke capacitie,
The other shewes but small discretion.
Who writes conclusions how to vse a peece,
In my conceit deserues a golden fleece.

who takes in hand to write of worthy warre,
And neuer march'd where any warre was made,
Nor neuer hopes to come in any iarre,
But tels the triall, knowing not the trade;
To write of warre, and note not what it is,
May well be thought a worke begun amisse.

But he that by his studie makes it knowne,
what thing warre is, and whereof it proceeds,
Defensiue and offensiue reasons shewing,
To those that gape for honor by their deeds,
A worthie worke who doth not count the seme,
In my conceit he doth a souldier shame.

If so: Smith's *trauell cannot well offend,*
For so he meant before he set it forth,
And if it chance to come where Souldiers wend;
Hee it commands to seeme of little worth:
For what he writes, he writes to honour those,
which wade in warres to triumph ouer foes.

Richard Hope Souldier.

RICHARD ROTHERVPPE Gentleman in commendation.

THat man whom Martiall attempts
May raise to honour high,
Let him peruse with learned skill,
Smiths *worke of Gunnerie.*

That fountaine which such springs sends forth,
Can neuer drie remaine:
I meane the Ground of Arts, from which
All science we attaine.

As Grammer, Musicke, and Physicke,
with high Astronomie:
And other Arts Mathematicke,
And braue Geometrie.

This Art of Gunnerie likewise,
Amongst the rest let stand,
whose god-father this Author is,
which tooke the same in hand.

Whose knowledge in this famous Art,
Deserues eternall fame,
For his conclusions excellent
Doth well deserue the same.

Richard Rotheruppe Souldier.

A Table shewing the deminite parts vsed for mensuration.

FOrasmuch as some of these measures are to be vsed in the Treatise following, it is requisite that I shew what kinde of measures are commonly vsed and now in force, beginning with a barly corne, frō whence all these hereunder and a great many moe doe proceed, as

An inch,		3 barley corns layed end to end.
a finger bredth,		4 barley cornes in thickneſſe.
a hand bredth,		4 fingers.
a foot,		12 inches.
a yard,		3 feet.
an ell,		5 quarters of a yard.
a ſpan,		3 handbredths.
a foot,		4 handbredths.
a geometricall pace,		5 feete.
a fadome,		6 feete, or 2 yards.
10 fadome,		a ſcore or 20 yards.
a furlong,		123 paces.
our Engliſh furlong,	cōtaineth	132 paces, or 660 feete.
a perch or rood,		5 yards ½ or 16 feet ½. (feet.
an aker,		160 perches, 528 paces, or 2640
a league, (mile		1500 paces.
an Italian or Engliſh		3 furlongs, or 1000 paces, or 5000
a Germane mile,		32 furlongs. (feet.
a ſcore,		20 yards.
an hundreth,		600 feet, after 5 ſcore to the 100.
24 grains of wheate		one penie of Troyes weight.
20 pence, (dry,		one ounce.
12 ounces,		one pound.
20 graines of barley,		one ſcruple of haberdepois weight.
3 ſcruples,		one dramme.
8 drammes,		one ounce.
16 ounces,		one pound.
112 pound,		100 weight.
a tunne,		20 hundreth.

A Table shewing how to weigh a great deale with few weights.

You may way any number of pounds from	one to 40 with these 4 weights,	1. 3. 9. 27.
	1 to 121 with these 5 weights,	1. 3. 9. 27. 81.
	1 to 364 with these 6 weights,	1. 3. 9. 27. 81. 243.

This rule of weighing many things with few weights, proceedeth of Geometricall progression. The pounds to be weighed, are wayed with as many namelike weights, to be done either double or three-fold, sometime by adding one weight to another, and sometimes by taking a-away and adding to the contrary ballance. Example in a double respect: All termes to 15 are weighed with 4 weights of pounds: as, 1.2.4.8. so in a triple respect, all pounds to 40 may be weighed with 4 weights, as 1.3.9.27. All pounds from 1 to 364 are to bee weighed with these 6 weights, 1.3.9.27.81.243. and so infinitely.

Mea-

Measures.

THe varietie of measures are in a manner infinite, and yet are all comprehended vnder three general kinds, proceeding from a point in Geometrie, as Arithmeticke doth from an vnite: that is to say, Lines, Superficies, Bodies.

Lines hauing but only length without bredth of thicknesse, doe measure onely Altitudes, Latitudes, and Longitudes, &c.

Superficies, being limited by lines, bearing length and bredth, without depth or thicknesse: in these are knowne the contents of Pauements, Glasse, Boord, Land, &c.

Bodies, being bounden by Superficies, and containing length, bredth, and thicknes, doe make knowne the quantitie of all solide or massiue things, as timber, stone, &c. All which requires the ayde of Arithmeticke, to be truly measured. The definitions, termes, and orderly working of these and all other, the Elements of Geometrie will teach you.

Here I thought to haue written briefly, or rather to haue glaunced at the wonderfull strange effects that Arithmeticke is able to worke and attaine to, but finding that that learned and famous man Master *Iohn Dee*, in his Mathematicall preface vpon *Euclids* Elements, doth notably touch the same, shewing the rare properties and incredible mysteries that numbers Art can reach to, affirming that the effects thereof, of man is not able fully to be declared, it soone strake me in the dumps, feeling my selfe farre vnable to soare so high.

How

How to finde the cubicall radix or roote of any number.

AS in my booke of the Art of warre, entituled, Arithmeticall militarie concluſions, I began with the extraction of ſquare rootes, being a ſpeciall rule to worke diuers feats belonging to the ſaid Art: So in this Treatiſe I haue thought beſt to begin & ſhew how to extract Cubicke rootes, for that diuers concluſions are to bee done by the ſaid rule, in the worke following, letting paſſe all former rules, as leſſe neceſſarie, the which are commonly knowne to euery childe, that hath any ſight in the Art of numbring.

To finde the radix or roote cubicall of any number, you muſt note how many figures or numbers bee in the totall ſumme thereof, and then as is ſhewed in the rule how to extract the ſquare root of any number, you make a pricke or point vnder euery other number, beginning at the firſt number towards your right hand: euen ſo in this rule, in ſearching for the cubicall roote of any number, you muſt put a prick vnder the firſt number towards your right hand, and ſo increaſe your number of prickes, vnder euery third number, towards your left hand, and your quotient will containe ſo many figures as there be prickes.

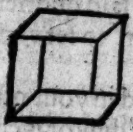
If your number propounded bee cubicall, multiplie your quotient cubically, the product of that multiplication will be the number that was propounded.

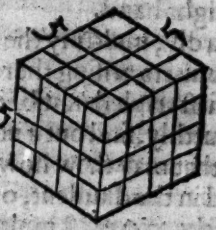
To multiply cubically, you muſt doe as this example ſheweth: 5 multiplied in himſelfe is 25, which 25 multiplied againe by 5, makes 125, and is a cubick number.

A cubicall figure, is proportioned as theſe figures ſheweth,

ſheweth, for a cube is a ſolide body of ſixe equal ſquares or ſides like a die,

Example.





It is requiſite in learning to extract rootes, to haue in perfect memorie all thoſe cubicke rootes of digit numbers, and the cubes they doe make, the which will bee a great helpe in working, the which I haue here ſet downe in a table after M. Records order.

1	1
2	8
3	27
4	64
5	125
6	216
7	343
8	512
9	729

Now to ſeeke for the firſt figure or roote, your table will ſhew you what number ſhall ſtand in the quotient, being due to the laſt pricke, towards your left hand, which figure ſo ſet in the quotient, multiplied cubickly, if it be equall to the number or numbers aboue that laſt pricke, it doth ſhew that the ſaid number or numbers are cubicke; but if it bee more than a cube number, then abate the greateſt cube number, that the quotient will make from the ſaid numbers, and cancelling the ſame, let the remaine ſtand ouer the head of the ſaid numbers,

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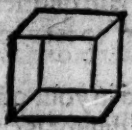

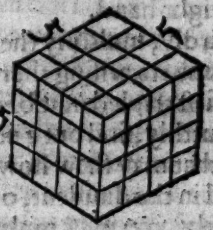

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as is done in diuiſion of common numbers, and ſo haue you done with the firſt pricke.

2 Secondly, triple your roote, ſetting the ſaid tripled number one place neerer from the laſt pricke, towards your right hand.

3 Thirdly, multiply the ſaid triple, by the ſaid quotient, the numbers ariſing thereof is your diuiſor, to ſet vnder your firſt tripled number.

4 Fourthly, find out a number to be placed in your quotient, that may ſhew how often times your diuiſor is contained in the diuident, or numbers ſo remaining ouer it.

5 Fiftly, you muſt multiply your diuiſor, by the number laſt placed in your quotient, firſt drawing a line vnder your diuiſor, and that which ariſeth of the ſaid multiplication muſt be placed vnder the ſaid line.

6 Sixtly, you muſt ſquare the number laſt placed in your quotient, and multiply the ſaid ſquare by the triple of your firſt quotient number, & the ſumme ariſing of that multiplication ſet vnder the line, one place neerer towards your right hand.

7 Seuenthly, multiply the number laſt placed in your quotient cubickly, and ſet the ſame cube numbers vnder the line, beneath the other numbers, one place neerer towards your right hand: and then drawing a line vnder the ſame, adde all thoſe numbers together; the ſumme ariſing abate from the other pricke that ſtands toward the right hand in your diuident, and if nothing remaine, the number propounded is a cubick number: but if any thing remaine, the number propounded is no cubicke number, but yet the quotient doth ſhew the neereſt cubicke roote in the propoſition.

In this order you muſt worke by euery prick, how ma-

ny

ny figures soeuer the numbers propounded containeth.

To finde a Denominator to the cubicke remaine.

If the number propounded be not cubicall, and that you desire to know the true denominator to the cubicall remaine, you must square your cubicke roote, and then triple the said square, and after triple the roote, adding all those summes together, and to the totall of the said addition, adde one vnite, so haue you the true denominator cubicall, the which you may abbreuiate into lesser termes by Abbreuiation, according to your desire.

Or you may finde the denominator cubicall, by multiplying the roote in the triple of another number that is more by one vnite nor the said roote: and then adding one vnite to the product of the said multiplication, you haue your desire.

An example how to worke, to finde the cubicke roote.

Admit the summe or numbers, whose cubicke roote you desire to know be 32768. I set the pricke vnder 8, & vnder the figure 2 standing in the fourth place, as in the worke here you see, and I finde that the greatest cubicke number in 32 is 27, and 3 is his roote, which 3 I place in the quotient, and his cube being 27, I substract from 32, so resteth 5. And so I haue done with the first prick towards my left hand, as here in the work you may see.

```
  05
32768(3
  27
```

Then I triple the quotient 3, & it is 9, which I set one place from the last prick neerer towards my right hand.

And then I multiply the triple of the quotient being 9, by the ſaid quotient 3, ariſeth 27, the which I place vnder 57, drawing a line vnder my diuiſor 27, and then I ſeeke how oft I can haue 27 the diuiſor in 57, which is a part of the diuident, the which I can haue but 2 times: which 2, I place in the quotient, and by the ſaid 2 I multiply the diuiſor 27, ſo ariſeth 54, which I place vnder the line vnder the diuiſor, as here you ſee.

05
32768(32
9
27
54

And then I ſquare the number laſt placed in the quotient being 2, and it is 4, which ſquare I multiply by the triple of the firſt quotient number being 9, ariſeth 36, which I place vnder 54, one place neerer towards the right hand, as here you may ſee. And then multiplying the digit 2. cubickly ariſeth 8, to bee ſet vnder the line one place neerer towards the right hand, & adding all theſe ſums together, there ariſeth 5768, the which ſubſtracted frō the number belonging to the firſt prick there remaineth nothing: ſo I ſay that 32768 is a cubicke number, and 32 is the true roote thereof. You may proue it by multiplying the quotient cubickly, and abating the product from the number propounded, there will remaine nothing.

0
05000
32768(32
27
54
36
8
5768

To finde the neereſt roote of a number not cubicke.

Queſtion.

I demand the true cubicke roote of 117884.

Reſolution.

The pricks placed in order as before, I find there will be but

but 2 figures in the quotient, & that the cubick nũber of 117 is 64, whose cubick root is 4, which 4 I place in the quotient, and his cube 64 being abated from 117, there remaines 53 to be placed ouer the last prick: then tripling the quotiẽt 4, ariseth 12 to be set down one place neerer towards my right hand, & then multiplying the quotient by the said triple, doth arise 48 for a diuisor, which I set in his place, drawing a line vnder him as in the former work you see. And then I make search how oft I can haue 48 in 538, which I can haue many times, but more than 9 times I must not take; and therefore I set downe 9 in the quotient, & multiplying the same by the diuisor 48, ariseth 432, to be placed vnder the line vnder the diuisor, then I doe multiply the said 9 squarely, ariseth 81, the which multiplied by 12 being the triple of the first quotient, ariseth 972, the which I set downe one place neerer towards my right hand; and then I multiply 9 cubickly, ariseth 729 to bee set downe yet one place neerer towards my right hand: and adding all those sums together, the totall is 53649, which abated from 53884, rests 235. And thus I affirme, that 49 is the neerest cubicke root in whole numbers of 117884, as here by the worke you may see.

```
 00
 53(2(3(5
117884(49
-------
 64
  12
  48
-------
 432
  972
   729
-------
 53649
```

Now to finde a denominator for the 235 remaining, I square the roote 49, so ariseth 2401. Then I triple the said squared number, and there ariseth 7203, and then I triple the roote 49, ariseth 147, to which I adde one, and it makes 148. All which sums ioyned together, makes 7351, and so the true cubicke root of 117884 is 49 and $\frac{235}{7351}$ parts of an vnite.

Theormes shewing the true proportion that a bullet of one mettall beareth to the like bullet of a contrary mettall, as also the proportion that the circumference of any bullet or globe, &c. beareth to the diameter, and of the superficiall content thereof to the diametrall square thereof, the which according to *Archimedes* are thus proued.

All circles are equall to that right angled triangle, whose containing sides, the one is equall to the semidiameter, the other to the circumference thereof.

The proportion of all circles to the square of their Diameter, is as 11 to 14.

All globes beare together triple that proportion that their Diameters doe.

The circumference of any circle, is more nor the triple of his Diameter, by such proportion as is lesse than $\frac{1}{7}$ and more nor $\frac{10}{71}$.

A bullet of Iron, to the like bullet of marble stone is in proportion as 15 to 34.

A bullet of lead to the like bullet of Iron, is in proportion as 28 is to 19.

A bullet of lead to the like bullet of marble stone is in proportion as 4 to 1.

The Diameter of any bullet, &c. is in proportion to the circumference as 7 to 22.

How by knowing the true weight of any one bullet, and the diameter of the peece due for the said bullet, to finde out the weight of any other bullet belonging to a contrarie peece of Ordinance.

Question.

Admit a Demy Cannon of 7 inches Diameter shoot

an

an Iron bullet of 32 pound weight, I demand what weight ſhall that bullet be of, that ſerues a Cannon of 9 inches diameter?

Reſolution.

To anſwer this and ſuch like, there is a generall rule; for *Euclid* in his ſixt booke of geometricall elements, hath demonſtrated and proued that all globes are in triple proportion to their Diameters, therefore I multiply the proportion of each bullet cubically, and I finde the cube of 7 is 343, and the cube of 9 is 729. Then by the rule of proportion I ſay, If 343 yeeld 32 pound weight, what ſhall that bullet weigh whoſe cube is 729? So multiplying 729 by 32 pound, the weight of the leſſer bullet, ariſeth 23328. which diuided by the 343, being the cube of the leſſer bullet, yeelds in the quotient 68 pound & $\frac{4}{141}$ parts of a pound, ſo much ſhall that bullet weigh, that ſerues a Cannon of 9 inches diameter, as by working the rule you ſhall finde.

Another eaſie concluſion, how by the weight of a ſmall bullet knowne, to finde out the weight of a greater.

Queſtion.

A bullet of 3 inches diameter weighing foure pound weight, what ſhall a bullet of the ſame mettall weigh whoſe diameter is twice the height of the former (that is 6 inches high?)

Reſolution.

I worke in the order of the former concluſion, multiplying the diameter of each bullet cubically, and diuiding as afore is ſhewed, the quotient is 32 pound weight, ſo much ſhall the greater bullet weigh.

In

Example.

In the laſt concluſion the weight of the greater bullet weighed 32 pound, being 6 inches diameter, how ſhall I finde the weight of a bullet of the ſame mettall that is but halfe that height.

Reſolution.

I finde the cube of 6 is 216, and the cube of 3 is 27, ſo framing the conuerſe rule of 3, I ſay: If 216 yeeld 32 pound weight, what will 27? And multiplying 27 by 32, and diuiding the product by 216, the quotient yeelds 4 pound, the true weight of the leſſer bullet. And note that if you know the diameter and weight of any bullet, and would know the weight of one that is but ½ the height of the firſt, the leſſer ſhall be in weight but the ⅛ part of the greater. Or knowing the weight of any bullet, if you would know the weight of another of the ſame mettall, being twice the height of the former, the greater ſhall weigh 8 times as much as the leſſer, as in a figure demonſtratiuely hereafter drawne you may ſee.

How by knowing the weight of any bullet whoſe diameter containeth both whole inches and parts of whole, how you ſhould worke to finde out the true weight of another whoſe diameter endeth with a fraction.

Queſtion.

If a Sakeret ſhoote a bullet of 2 inches ½ diameter, of 5 pound weight, what ſhall a Culuering ſhot weigh of 5 inches ½ diameter?

Reſolution.

To anſwer this or ſuch like, I reduce each bullet into his

his proper fraction, and I finde that the bullet of 2 inches $\frac{3}{4}$ diameter will be in a fraction $\frac{11}{4}$ or 2 11 quarters, & the Culuering bullet of 5 inches $\frac{1}{4}$ height, will be $\frac{21}{4}$; then I multiply each of these 2 fractions cubically, and I finde that the cube fraction of the lesser bullet is $\frac{1331}{4}$ and the cubicke fraction of the greater is $\frac{9261}{4}$ which known, I set down vnder three pound (the weight of the lesser bullet) the vnite 1, and it will represent a fraction thus $\frac{1}{3}$, and then multiplying and diuiding by the golden rule in fractions, I finde that the weight of the Culuering shot of 5 inches $\frac{1}{4}$ diameter will weigh 20 pound weight and almost $\frac{1}{4}$ pound, as in the working you may finde.

How by knowing the diameter and weight of an iron bullet, to finde the weight of a bullet of marble stone of the like diameter: or how by knowing the weight and height of a bullet of marble, to finde out the weight of an iron bullet of like height.

Question.

Admit an iron bullet of 4 inches height weigh 9 pound, I demand what shall a bullet of marble stone weigh of like diameter.

Resolution.

In a theoreme afore mentioned, I finde that a bullet of iron to the like bullet of marble stone, shall beare such proportion as 34 is to 15. And therefore I multiply the weight of the iron bullet knowne being 9 pound by 15, (the proportion the stone bullet beareth thereto) so ariseth 135, which diuided by 34, the quotient is 3 pound, and $\frac{33}{34}$ parts of a pound: that is, 4 pound wanting $\frac{1}{34}$ part of a pound, so much shall the bullet of marble stone weigh that is in Diameter and Circumference, equall to

the like bullet of iron. In like order reducing the weight of the ſtone bullet into his proper fractiō, you ſhal haue $\frac{15}{15}$ pound, which diuided by 15, the proportiō the ſtone bullet beareth to the like bullet of iron, your quotient is 9, the number of pounds that the irō bullet weigheth.

How by knowing the height and weight of an iron bullet, to finde out the weight and height of the like bullet of lead, or how to finde the weight of an iron bullet, by knowing the weight of a leaden bullet of like diameter.

Queſtion.

There is a Cannon that ſhootes an iron bullet of 72 pound weight, what ſhall a bullet of lead of the ſame diameter weigh? *Reſolution.*

To worke this, I note that the theoreme before ſaith, that a bullet of iron to the like bullet of lead, ſhall beare ſuch proportion as 28 is to 19, therefore I multiply 72 (the pounds which the iron ſhot weigheth) by 28, ſo ariſeth 2016, which diuided by 19, the quotient is 106 pound $\frac{2}{19}$, ſo much will a leaden bullet weigh that is proportionall to an iron bullet of 72 pound weight.

In this order by working as I haue ſhewed in the end of the laſt concluſion, you may by knowing the weight of the leaden bullet, finde out the weight of the like bullet of iron.

How you may find out the weight of any ſtone bullet of marble, by knowing the weight of the like bullet of lead, or how by knowing the weight of the ſtone bullet to finde out the weight of a leaden bullet of like proportion.

Queſtion.

If a bullet of lead weigh 106 pound, what ſhall a bul-

let

let of marble ſtone weigh of the ſelfe like proportion?

Reſolution.

To anſwer this, I finde that a bullet of lead to the like bullet of marble, beareth ſuch proportion as 4 to 1. Therfore multiplying 106 by 1, and diuiding the product by 4, the quotient will be 26 pound & $\frac{2}{4}$, ſhewing the true weight of a ſtone bullet, that is proportionall to the like bullet of lead.

And now to finde out the weight of the leaden ſhot, by knowing the weight of the ſtone ſhot, reduce the ſtone bullet into his proper fraction, you ſhall haue $\frac{26}{2}$, & ſetting 1 vnder 4 fraction wiſe, multiply the numerators together, and likewiſe the denominators, and diuiding the product ariſing of the numerators by the product of the denominators, your quotient will bee 106 pound, ſhewing the true weight of the leaden bullet.

If you haue or doe know the weight and true height of a bullet of ſtone, or any other mettall, & are deſirous to know the weight and height of another bullet that is greater or leſſer, and of the ſame mettall, in working as the firſt concluſion ſheweth, you ſhall haue your deſire.

To finde out the circumference of any circle or bullet.

Queſtion.

I demand how many inches is about the circumference of that bullet whoſe diameter is 9 inches.

Reſolution.

To work this or any ſuch like, there is a general rule, as thus, that the proportion of the diameter to the circum-

ference is as 7 to 22, therefore multiplying the diameter 9 by 22 ariseth 198, which summe diuided by 7, the quotient is 28, $\frac{2}{7}$ shewing the true number of inches about the circumference of a bullet of 9 inches diameter, as the figure here demonstrated sheweth.

How you may by knowing the circumference of any bullet, finde out the height or diameter of the same.

Question.

The circumference of the bullet in the last conclusion, contained 28 inches $\frac{2}{7}$ as in the demonstration you may see, I would know how I should worke to finde how many inches the diameter of the same is.

Resolution.

To worke this and all such like, I must worke contrarie to the former conclusion, first reducing the whole number and broken, being 28 inches $\frac{2}{7}$ into his proper fraction, and it will be $\frac{198}{7}$ then multiplying by 7 according to *Archimedes* doctrine, and diuiding by 22, the quotient will be 9, so many inches is the diameter of the same bullet.

In this order you may finde out the diameter and circumference of all other bullets.

How to finde out the solid content of any bullet, &c.

Question.

There is a bullet of iron whose diameter containeth 9 inches, how many square inches is in the solid content thereof?

Resolution.

To know this and all such like, there is a generall rule, as thus, to multiply the diameter in his square, I meane cubically, and then multiply that product by 11, diuide the totall summe by 21, the quotient sheweth the number of square inches in that spherical globe or bullet, for 9 multiplied cubically ariseth 729, which augmented in 11 is 8019, that totall diuided by 21, yeeldeth 381 inches, and $\frac{1}{7}$, so many square inches of iron will be in a bullet of 9 inches diameter.

To finde the true content of the superficies of any circle drawne upon a flat, as on a table or paper, &c.

Question.

There is a circle whose diameter is 21 inches, I demand how many square inches is contained within the circumference of the same?

Resolution.

To resolue this or such like, there is a generall rule, in taking $\frac{7}{11}$ the diameter, and multiplying it in $\frac{3}{7}$ the circumference, or squaring the diameter, and multiplying the product by 11, and diuiding the result by 14, the

quotient sheweth the Area or content of all the superficies within the circumference thereof. *Example:*

The square of 21 is 441, which multiplied by 11 is 4851, that diuided by 14, yeeldeth in the quotient 346 inches $\frac{1}{2}$. Or other waies, take the halfe of 21 inches, that is, 10 inches $\frac{1}{2}$, & take $\frac{1}{7}$ of the circumference, which is 33 inches, reduce them into fractions according to the rule, you haue $\frac{11}{1}$ for the diameter & $\frac{11}{1}$ for the circumference, then multiplying the one by the other, the product is $\frac{121}{1}$, which diuided by the denominator 2, yeeldeth in the quotient $346\frac{1}{2}$ as before. In this order you may find out the content of the plaine of any circle.

To finde out the circumference of any bullet or globe diuers and sundrie waies.

Question.

How many inches is about the circumference of that bullet or globe, whose diameter is supposed to be 21 inches high? *Resolution.*

After you haue with your callapar compasses, found out the height of the diameter, multiply the same by 22, so there will arise 462, the which diuided by 7, the quotient will be 66 inches, the true measure of the circumference. *Another way.*

Triple your diameter, and thereto adde the $\frac{1}{7}$ part of the same, your product is the circumference. *Example:* The triple 21 is 63, and the $\frac{1}{7}$ part of 21 is 3, which added to 63 is 66 inches, as before.

Another way to worke the same.

Looke how many times you can haue 7 in the diameter, so many times must you haue 22 in the circumference. *Example.* The diameter being 21 inches, diuided by 7, yeelds in the quotient 3, by which if you multiply

22

22, your product will be 66 inches, for the circumference, as before. In this order you may find out the circumference of any bullet, or ſpherical body, &c.

To finde out the ſuperficies of any round body, as bullet, globe, &c. diuers and ſundry waies.

Queſtion. I haue a demy Cannon bullet of 7 inches diameter, I demand how many inches the ſuperficiall content thereof is?

Reſolution. To anſwer this and all ſuch like, I muſt in the order before ſhewed, find out the circumference of the bullet, and I finde that a bullet of 7 inches diameter, ſhall containe 22 inches in circumference, which circumference being multiplied in the diameter, ariſeth 154 inches, the true number of inches contained vpon the ſuperficies of a bullet of 7 inches diameter.

Another way.

Multiply the ſquare of the diameter of any bullet or globe by $\frac{22}{7}$ the product is your deſire. *Example:* The bullet whoſe diameter was 7 inches being ſquared, the ſquare thereof is 49, which multiplied by 22, yeeldes 1078, which ſum diuided by 7, the quotient is 154 inches as before.

Another way.

Diuide the ſquare of the circumference of any bullet by $\frac{11}{7}$ your quotient numbers will ſhew you the ſuperficiall meaſure of the ſame. *Example.*

The circumference of the bullet aforenamed of 7 inches diameter containeth 22 inches, the ſquare thereof is 484 inches, that nũber diuided by $\frac{11}{7}$ as you do in fractions, in ſetting an vnite vnder the ſquare number thus, $\frac{484}{1}$ & multiplying the ſaid ſquare number by the denominator of the other fraction being 7, ariſeth 3388, which diuided by the numerator 22, the quotient

is

is 154 inches, the superficiall content thereof, as before.

How you may finde out the solid content or crassitude of any round bullet or globe, &c. diuers wayes.

Question.

In the question before propounded of the bullet, whose diameter was 21 inches, I would know how many inches be in all the solid or massiue content therof?

Resolution.

I multiply the diameter cubickly, and after multiplying that cubicke number by 11, ariseth 101871, the which diuided by 21, my quotient is 4851, shewing there is so many inches in the solid content of a bullet or globe of 21 inches diameter.

Another way.

Multiply the cube of $\frac{1}{7}$ the circumference by 49, and diuide the product arising thereof, by 363, your quotient will shew your desire. *Example:* The circumference of a bullet whose diameter is 21 inches, containeth 66 inches, the $\frac{1}{7}$ thereof is 33 inches, the cube whereof is 35937, that summe multiplied by 49 is 1760913, which diuided by 363, the quotient is 4851 inches as before.

How you may by knowing the diameter and weight of any bullet, or other round body, finde out the diameter of any bullet or globe that weigheth twice the weight of the former.

Question.

There is a demy Culuering bullet of 4 inches diameter weighing 9 pounds, I demand the true height of that

that bullet which weigheth 18 pound weight.

Resolution.

To worke this and all such like demands, this rule is generall in multiplying the height of the lesser bullet whose weight is knowne cubically, then doubling that summe, and extracting the cubicke roote thereof, the quotient will answer your question. *Example.* The bullet afore-named of 4 inches diameter being multiplied cubically is 64, that summe doubled is 128, the cubicke roote thereof is 5 inches and a fraction remaining scarce the $\frac{1}{10}$ part of an inch, shewing the true height of a bullet that weigheth 18 pound. In this order if you haue a bullet that is 3 times as heauie as another of like mettall, whose weight is known, and that you desire to know the diameter of the greater bullet: in tripling the cubicke number of the lesser bullet whose diameter is knowne, & extracting the cubicke roote thereof, you shall finde out the true height of the greater bullet. Or if you would find out the height of any bullet of like mettal, that weigheth 4 times as much as an other bullet whose weight is knowne, quattiple the cubicke number of the diameter of the lesser bullet, and extract the cubicke root thereof, your quotient will satisfie you. Or if 5 or 6 times, &c. in working as I haue shewed you may finde your request.

How you may Geometrically finde out the diameter of any bullet, that weigheth twice as much as another knowne bullet.

Take the true height or diameter of the lesser bullet whose weight you know, and square the same as you see in the figure following. Then draw a line that may diuide

the ſaid ſquare in 2 equall parts, in the 2 oppoſite angles, and that line ſhall be the diameter of a bullet twice the weight of the other: then diuide that diametrall line in 2 equall parts, ſetting one foot of your compaſſe in the center or mids thereof, and with the other foot draw a circle, and that circumference will repreſent the proportion of a bullet, twice as much in weight as the leſſer.

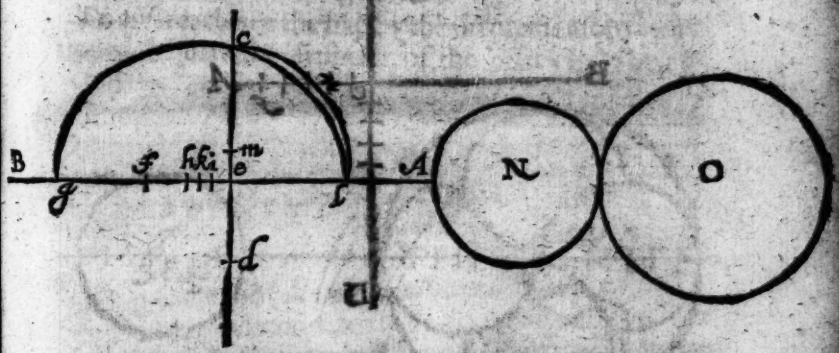
How you may Arithmetically proue this concluſion.

The diameter of the leſſer bullet is 5 inches, the ſquare of it is 25. that ſum double is 50. the ſquare roote of 50, is 7. and ſo much is the diameter of the greater bullet, as in the figure here drawne you may ſee.

Another way Geometrically, to finde the diameter of any vnknowne bullet that is double the weight of a knowne bullet.

Draw a ſtraight line of what length you thinke good, as you ſee the line A. B. then draw another croſſe line perpendicular to the ground line as you ſee the line C. D. note the meeting or croſſing of the lines, as is the point E. This done, open your compaſſe the iuſt length

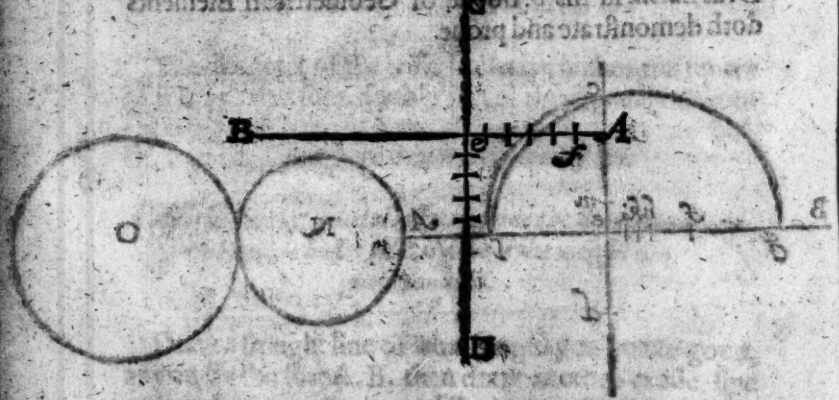
of the diameter of the leſſer bullet whoſe weight you would double, ſetting one foot of the compaſſe in E. and the other in D. and meaſure towards B. twice that diameter, as is done in the points F. G. Then diuide the line E. F. in 2. equall parts in the point H. and after diuide the line E. H. in 2 equall halfes, as in the point I. And laſtly diuide the line I. H. in 2 equall parts in the point K. Which done, open your compas, placing one foot in K. and the other in G. draw a circle, as you ſee, I doe the ſemicircle L. C. G. After diuide the line C. D. in 2 equall parts in the point M. and opening your compaſſe the iuſt widenes of one of thoſe parts, ſet one foot in M. and with the other foot draw the line C. N. L. Which done, the bullet whoſe diameter is the line L. E. will weigh twice as much as the bullet whoſe diameter is the line E. D. as *Euclid* in his 6. booke of Geometricall Elements doth demonſtrate and proue.



The greater circle O. doth ſhew the proportion of a bullet that weigheth twice as much as the leſſer circle N. both the ſaid bullets being caſt of one like mettall.

Another demonstration to proue the former conclusion by numbers.

In a conclusion before set downe, where the bullet of a demy Culuering of 4. inches diameter weighed 9 pound, I proued that a bullet whose weight was 18 pound should be more than 5 inches diameter. Euen so I haue here vnder diuided the line E.D. of the former conclusion, being supposed to be the diameter of a bullet whose weight is knowne, into 4 equall parts or inches. And likewise diuiding the Diameter F.E. into the like diuisions it containeth 5 of those parts, and almost the $\frac{1}{10}$ part of an inch more, shewing the true height of a bullet that is twice as much in weight as the lesser bullet of 4 inches diameter, as this figure sheweth.



As the vpper face or side of any square being doubled, the square arising of that doubled side shall be in proportion iust 2 times as much as the first square was, whereas

a great many would think it would be but twice as much. Euen so the diameter of any circle being doubled, the Area or superficiall content of the flat of the same circle so doubled, shall be foure times as much as the other. Also any cube, globe or bullet, whose diameter is in double proportion to another, the solide content of that bullet whose diameter is so doubled, shall be in weight 8 times as much as the lesser, as these two examples in the conclusions following figuratiuely drawne, sheweth.

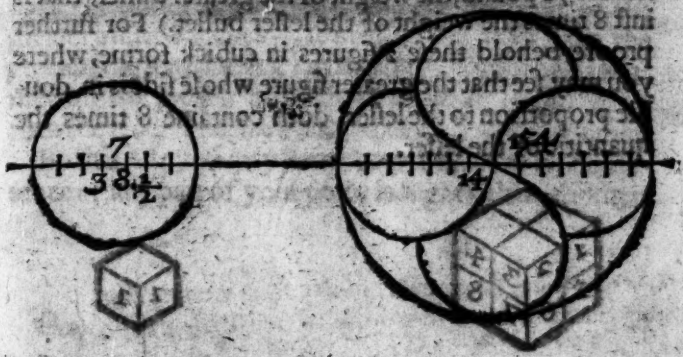
How by knowing the superficiall content of the plaine of any circle, to finde out the superficiall content of another that is twice the diameter of the first.

Question.

There be two circles drawne, the one 7 inches diameter, the other 14 inches: how much is the content of the greater circle more than the lesser?

Resolution.

To answer this or the like, by the theoreme afore mentioned, I square the diameter of the lesser circle being



ſeuen inches, ſo ariſeth 49 inches, that ſquare multiplied by 11, yeelds 539, the which diuided by 14, the quotient is 38 inches ½ ſhewing the ſuperficiall content of the circle of 7 inches diameter. Alſo working in the ſame order, I finde the content of the greater circle of 14 inches diameter to containe 154 inches, which diuided by 38. ½ the quotient is 4, ſhewing that the ſuperficiall content of the greater circle is iuſt 4 times as much as the leſſer.

By knowing the weight and height of any one bullet to finde out the weight of another of twice the height of the former.

Queſtion.

If a bullet of 4 inches diameter weigh 9 pound, how much ſhall a bullet of 8 inches height weigh.

Reſolution.

To know this or the like, multiply the diameter of each bullet cubically, & I finde the cube of 4 is 64, & the cube of 8 is 512, which knowne, I frame the rule of proportion, ſaying, If 64 yeeld 9 pound, what will 512? and in multiplying and diuiding according to the rule, my quotient is 72 pound, the weight of the greater bullet, (that is iuſt 8 times the weight of the leſſer bullet.) For further proofe, behold theſe 2 figures in cubick forme, where you may ſee that the greater figure whoſe ſide is in double proportion to the leſſer, doth containe 8 times the quantitie of the leſſer.

An

An easie rule to finde out the diameter of any bullet, and how to know how much one bullet is higher than another by Arithmeticke skill, without any callaper compasses.

If you want a paire of callaper compasses, take a line or a garter, &c. and gird the bullet or bullets whose height you desire iust in the mids, laying that measure to an inch rule, noting how many inches or other measure the same containeth, then multiplying the said measures by 7, and diuiding by 22, the quotient will shew you your request. And then abating the lesser diameter from the greater, the remaine will shew you how much the one is higher than the other.

Example.

Suppose the circumference of the one bullet be 16 inches, and the circumference of the other 26 inches, in working as aboue is taught, I finde the diameter of the lesser bullet is 5 inches $\frac{1}{11}$ and the diameter of the greater bullet 8 inches $\frac{7}{11}$, so abating the lesser from the greater, the remaine is 3 inches and $\frac{6}{11}$ parts of an inch, shewing the greater bullet is so much in height more than the lesser. The like is to be obserued with any other.

By this rule you may know how much the circumference or any part of your peece is higher than another:

A Table shewing the weight of all Iron bullets from the Farconet to the Cannon in Habberdepois weight.

Height of the shot in inches and parts of inches.	Weight of the shot in pounds and parts of pounds.	Height of the shot in inches and parts of inches.	Weight of the shot in pounds and parts of pounds.
Height.	Weight.	Height.	Weight.
2.	1. 1/7	5. 1/8	19. 2/3
2. 1/4	1. 3/4	5. 1/2	22. 1/7
2. 1/2	2. 1/3	5. 3/4	25. 5/6
2. 3/4	3. 3/7	6.	29. 2/3
3.	4. 1/2	6. 1/4	32. 1/2
3. 1/4	5.	6. 1/2	36. 5/8
3. 1/3	6. 2/3	6. 3/4	40. 3/4
3. 1/4	7. 6/7	7.	46.
4.	9.	7. 1/4	52. 6/7
4. 1/4	10. 1/2	7. 1/2	56. 5/8
4. 1/2	12. 1/7	7. 1/8	64. 1/2
4. 1/4	14. 5/9	8.	70.
5.	16. 1/4	8. 1/4	76. 1/2

How you may arithmetically know the true breadth of the plate of the ladle that is due for any peece of Ordinance, by knowing the height of the bullet fit for the said peece.

Take a line and compasse the bullet in the mids, laying the same measure to an inch rule, diuide the same measure into 5 equall parts, 3 of those parts is the iust breadth you ought to make your plate of, which being orderly placed on the staffe, and bent circularly, serues to hold the powder in the other $\frac{2}{5}$ parts being cut and taken away, and so left open, serues to turne the powder into the peece, the which to doe Gunner-like, as soone as you haue filled the ladle so full that you may strike the same with a rule, and put the same into the mouth of the peece, fixe your thombe vpon the vpper part of the staffe, towards the end next the tampion or head thereof, and so thrusting the ladle gentlie home to the breech of the peece, turne the rammer staffe, so as your thombe fall directly vnder the staffe, and so shall you empty your ladle orderly.

Now to know the $\frac{3}{5}$ parts of the bullets circumference, that you may make the plate of your ladle orderly, & of that iust breadth, lay the measure of the whole circumference to an inch rule, and then multiply the same by 3, and diuide the product by the denominator 5, your quotient will tell you truely the breadth that the plate of your ladle ought to be of.

Example.

A Cannon whose bullet is 7 inches high, will be 5 $\frac{1}{5}$ inches

inches in the circumference, that multiplyed by 3 is 66, which diuided by 5, the quotient is 13 inches $\frac{1}{5}$, the true breadth that the plate for a cannon ladle of 7 inches diameter ought to be of.

The length of the ladle is to be made according to the length, height, and weight of the peece for which it is made, which in a table in the end of the booke you may finde set downe for all sorts of peeces.

How to make a ladle for a chamber-bored peece.

Open your compasse the iust diameter of the chamber, within $\frac{1}{10}$ part of an inch thereof. Diuide that measure in 2 equall parts, then set your compasse to one of those parts, and with the one foote fixed on a paper or smooth boord, draw with the other foot a circle, the diameter thereof will be a iust quarter of an inch shorter than the diameter of the chamber-bore, by the circumference whereof, you may finde out the true breadth of the plate of a ladle that is fit for such a chamber-bored Cannon, by the rule afore set downe how to finde the true breadth of the plate of any ladle, for any other peece of Ordinance, in taking the $\frac{1}{7}$ parts of the circumference thereof, the length ought to be twice the diameter, and $\frac{2}{7}$ parts, to hold as 2 times the iust quantitie of corne powder that is due to charge such a chamber-bored cannon with.

Example.

The diameter of the circle drawne for any cannon whose chamber-bore is 7 inches, containeth 6 inches $\frac{5}{29}$, the circumference whereof is 21 inches $\frac{6}{7}$, the $\frac{1}{7}$ parts thereof is 3 inches $\frac{1}{35}$, and so much ought that ladle to

be in breadth, and in length it ought to be 18 inches. In this order you may worke to make a ladle in length and breadth for any bel-bored Cannon: and to finde out the thicknesse of the mettall at the touch-hole, or the height of the bore thereof, this conclusion following will shew you.

How to finde out the height or diameter of the chamber, in any chamber-bored Cannon, or other peece of Ordinance, and how to finde out the thicknesse of the mettall round about the chamber thereof.

Take your priming iron, or else a straight peece of wyer, and bow the end thereof in manner of a hook, and then put the same into the touch-hole, downe to the lowest part of the concauity of the peece, and then with your knife or else with a peece of chalke, make a stroke vpon the wyer hard by the vpper part of the mettal, without the peece at the touch-hole, then measure by your inch rule, how long the wyer is from that stroke to the end. After put in the same wyer againe, and pull it vp, so as the bowed end may rest or stay within the cilinder or concaue of the peece: and make another marke or stroke on the said wyer, hard by the vpper part of the mettal; the distance betweene those two strokes, is the just thicknesse of the mettall round about the chamber, the which abated from the length of the wyer (I meane from the first stroke to the lowest end) the remaine is the true diameter of the chamber bore in the peece.

Example.

Admit the length of the wyer from the end of the con-

cauity to the first stroke containeth 15 inches, and the distance betweene the 2 strokes is 8 inches: then those 8 inches is the iust thicknesse of the mettall about the chamber, which abated from 15 inches, resteth 7 inches, the iust diameter of the chamber in such a peece.

By Arithmeticke skill, how to know whether the caryage for your peece be truly made or not: or how the caryage for any other peece of Ordinance ought to be made.

Measure the iust length of the Cilinder or bore of your peece, the plankes of your caryage ought to bee once and a halfe that length. Also measure the diameter of the peece, and the said plankes at the fore end should bee in depth 4 times the diameter, and in the midst 3 times and ½ the diameter, and at the end next the ground, two times and ½ the diameter, and in thicknesse once the diameter.

Example.

Admit a Culuering of fiue inches diameter is in length in the bore thereof 20 times that measure (that is, 10 foote long,) then I say that the plankes of her caryage ought to bee 15 foote in length, and at the fore end next the peece 2 foote in breadth, and in the midst one foote three quarters, and at the lowest end next the ground one foote and a quarter: and in thicknesse halfe a foote. Also euery caryage ought to haue foure transomes, and ought to be strengthened with strong Iron bolts.

The holes or centers wherein the trunions ought to lye, ought to be three times and ½ the diameter from the foure end of the carryage, and in depth ⅓ parts of the thicknesse of the trunions, which depth you may easily finde out, as thus: take the height or diameter of the trunions, and multiply the same measure by 5, and dividing by the denominator 32, the quotient will shew your desire.

How by knowing the weight of any one peece of Ordinance, to finde out the weight of any other.

Question.

If a Saker of foure inches diameter weigh 1600 pound weight, what will a Culuering weigh that is five inches diameter?

Resolution.

Some would thinke that the rule of proportion plainly wrought, would answer this question: but in that they are deceiued; for the content of solide bodyes being massie, are Sphericall or Cubicall in proportion, therefore you must multiply the diameters of euery peece cubically, & set downe the weight of the peece knowne in the middle number, and so working according to the rule of proportion, you shall finde out the true weight of the greater peece.

Example.

4 inches the diameter of the lesser peece, multiplied cubically, ariseth 64 inches. Likewise the cubicke num-

ber of the diameter of a Culuering of 6 inches high, is 216 inches: then framing the rule of proportion, I say, If 64 being the cube of 4 yeeld 1600 pound weight, (being the weight of a Saker of 4 inches bore) what will 216 being the cubicke number of 6 inches, so multiplying 216 by 1600, ariseth 345600. which diuided by 64 yeeldes in the quotient 5400 pound weight, so much weigheth the Culuering of 6 inches diameter.

In working by the conuerse rule of proportion, you may not onely prooue this conclusion, but also may find out the weight of any lesser peece of Ordinance, by knowing the weight of a greater.

Example.

If 216 being the cube of 6 inches, yeeld 5400 pound in weight, what will 64 being the cube of 4 inches: so multiplying 5400 by 64 there ariseth 345600. which diuided by 216, the quotient is 1600 pound weight, shewing the true weight of the Saker of 4 inches diameter, as before.

Or if the diameters of the peeces whose weight you would know, containe both whole numbers and broken, in reducing each diameter into his proper fraction, and multiplying the same cubically, setting down the weight of the peece knowne, in the middle place, for the second number, and multiplying and diuiding as afore is taught, the quotient will shew you your request, as the conclusion following will teach you.

Question.

If a demy Culuering of 5 inches $\frac{1}{2}$ diameter weigh 3600 pound weight, what will a Cannon of 7 inches $\frac{3}{4}$ diameter?

Resolution.

I reduce the diameter of each peece into his proper fraction, and I finde that the broken number of 5 inches $\frac{1}{4}$ diameter contayneth $\frac{21}{4}$ which multiplied cubically ariseth $\frac{9261}{64}$. Likewise I reduce the diameter of the Cannon, being 7 inches $\frac{1}{4}$ into his fraction, and it is $\frac{29}{4}$ whose cube is $\frac{24389}{64}$: then I set an vnite 1 vnder 2600, and it doth represent a fraction thus $\frac{2600}{1}$. Now to finde out the weight of the greater peece, I set down these 3 new made fractions in the order of whole numbers, and working by the rule of proportion, I finde the greater peece weigheth 8363 pound, and almost $\frac{1}{2}$ of a pound: for in multiplying 29791 by 2600, there ariseth 77456600, the which augmented by the denominator 4, maketh 309826400 for the diuident or number to be diuided. Likewise the fraction of the lesser peece being 9261, multiplyed by his denominator 4, makes 37044 for a diuisor, which diuident being diuided by the diuisor, yeeldeth in the quotient 8363 pound, and certaine parts of a pound, so much will a Cannon of 7 inches $\frac{1}{4}$ weigh being proportionall in mettall to the other peece.

How you may by Arithmeticall skill, know how much of euery kinde of mettall any brasse peece of Ordinance containeth.

Question.

Euery Gun-founder doth commonly vse for euery 100 pound weight of copper, to put in 10 pound weight of Lattin, and 8 pound weight of pure Tinne: I demand how many pound weight of euery of those mettals is in

in a Culuering of 5600 pound weight?

Resolution.

To answer this or all such like, I ioyne all the seuerall mixtures together, and they make 118 pound, which I reserue for my diuisor. Then I multiply the weight of the peece by euery mixture seuerally, and there ariseth of the 100 weight of copper being the greatest mixture, 560000, the which sum is to be diuided by the diuisor common (to wit, 118 pound) and the quotient is 4745 pound and $\frac{70}{118}$ parts of a pound: so much copper is in the said peece. Now to know how much latin is in the same, I multiply the whole weight of the peece by 10. the second mixture, and the product is 56000. which number diuided by the diuisor common, the quotient is 474 pound $\frac{28}{118}$: so much latin is in the same peece. And lastly to know how much Tin was in the same peece, I multiply the weight of the peece by 8, ariseth 44800, which diuided by the diuisor 118, the quotient is 379 $\frac{78}{118}$: and so much Tin was put into the said peece.

Now to proue the worke if it bee truely wrought or not, I adde all the 3 quotients together, and because they doe all make the true sum of the whole weight of the peece according to the proposition, I affirme the same to be truely wrought.

Note. The Gun-founders doe hold and affirme, that the Latin doth incorporate, and causeth the peece to bee of a good colour, and the Tin doth strengthen and binde the other mixtures.

How

How you may know how far any peece of Artillery will conney her bullet at the best of the randon, by knowing the vtmost range and point blancke of another peece, and how to proue the same, by which rule, you may know how far any peece will reach at point blancke and vtmost range.

Question.

If a Saker at point blanke conney her bullet 200 paces, and at the best of the randon shoot 900 paces, what will that Cannon do which at point blancke shoots 360 paces?

Resolution.

To resolue this or the like, I set downe the numbers proportional according to the rule, multiplying 900 paces (the vtmost randon of the Saker) by 360 paces, (the point blanke of the Cannon,) so ariseth 324000, which diuided by 200 the number of paces the Saker shoots at point blanke, the quotient is 1620. And so many paces will a Cannon shoot at the best of the randon, that at point blanke rangeth 360 paces, as by working you may finde, and by experience better vnderstand.

You may proue this conclusion by the conuerse rule of proportion, multiplying 900 the number of paces the Saker shoots at the best of the randon, by 360, the paces that the Cannon shoots at point blancke, and diuiding that product 1620 the number of paces the Cannon shoots at the best of the randon, the quotient is 200, shewing the number of paces that the Saker shall shoot at point blanke. In this order you may worke the like conclusion by any other peece of Artillery, and find out the point blanke and vtmost range thereof.

in a Culuering of 5600 pound weight?

Resolution.

To answer this or all such like, I ioyne all the seuerall mixtures together, and they make 118 pound, which I reserue for my diuisor. Then I multiply the weight of the peece by euery mixture seuerally, and there ariseth of the 100 weight of copper being the greatest mixture, 560000, the which sum is to be diuided by the diuisor common (to wit, 118 pound) and the quotient is 4745 pound and $\frac{30}{118}$ parts of a pound: so much copper is in the said peece. Now to know how much latin is in the same, I multiply the whole weight of the peece by 10. the second mixture, and the product is 56000. which number diuided by the diuisor common, the quotient is 474 pound $\frac{28}{118}$: so much latin is in the same peece. And lastly to know how much Tin was in the same peece, I multiply the weight of the peece by 8, ariseth 44800. which diuided by the diuisor 118, the quotient is 379 $\frac{78}{118}$: and so much Tin was put into the said peece.

Now to proue the worke if it bee truely wrought or not, I adde all the 3 quotients together, and because they doe all make the true sum of the whole weight of the peece according to the proposition, I affirme the same to be truely wrought.

Note. The Gun-founders doe hold and affirme, that the Latin doth incorporate, and causeth the peece to bee of a good colour, and the Tin doth strengthen and binde the other mixtures.

How

How you may know how far any peece of artillery wil conuey her bullet at the best of the randon, by knowing the vtmost range and point blancke of another peece, and how to proue the same: by which rule, you may know how far any peece will reach at point blancke and vtmost range.

Question.

If a Saker at point blanke conuey her bullet 200 paces, and at the best of the randon shoot 900 paces, what will that Cannon do which at point blancke shoots 360 paces?

Resolution.

To resolue this or the like, I set downe the numbers proportional according to the rule, multiplying 900 paces (the vtmost randon of the Saker) by 360 paces, (the point blanke of the Cannon,) so ariseth 324000, which diuided by 200 the number of paces the Saker shoots at point blanke, the quotient is 1620. And so many paces will a Cannon shoot at the best of the randon, that at point blanke rangeth 360 paces, as by working you may finde, and by experience better vnderstand.

You may proue this conclusion by the conuerse rule of proportion, multiplying 900 the number of paces the Saker shoots at the best of the randon, by 360, the paces that the Cannon shoots at point blancke, and diuiding that product 1620 the number of paces the Cannon shoots at the best of the randon, the quotient is 200, shewing the number of paces that the Saker shall shoot at point blanke. In this order you may worke the like conclusion by any other peece of Artillery, and find out the point blanke and vtmost range thereof.

To know how much a bullet of yron will out flie a bullet of lead of the like diameter, being both discharged out of one peece, with one like quantitie in powder.

Question.

If a bullet of lead of 24 pound weight, being shot out of a peece with $\frac{1}{7}$ parts of the said bullets weight in powder, range at point blanke 240 paces, how farre will a bullet of yron of like height range, being discharged out of the said peece at point blanke with the like quantitie of powder?

Resolution.

The proportion betweene a bullet of yron and a bullet of lead of the same height, I haue shewed by the theoremes and conclusions afore set downe: by which I finde that a bullet of yron being of equall diameter to a leaden bullet of 24 pound weight, the said yron bullet shall weigh 16 pound $\frac{1}{7}$ parts. And for as much as the leaden bullet is shot with $\frac{1}{7}$ parts in powder of his weight, that is, with 16 pound of powder, which is very neare the full weight of the yron bullet, I finde that the said bullet of yron shall out flie the leaden bullet $\frac{1}{7}$ part of the leuell range (that is) the yron bullet shall flie being shot as afore at point blanke 320 paces, that is, 80 paces further than the leaden bullet rangeth at point blanke. But if the peece out of which the said bullets were shot, had beene mounted at any number of degrees of randon, the range of the yron bullet would shorten somewhat of the $\frac{1}{7}$ of the ouerplus of the said range: so that if the peece were mounted to the best of the randon, the said bullet of yron would not out flie the leaden bullet, not the $\frac{1}{7}$ part of the said range.

By knowing how much powder is sufficient to charge any one peece of Ordinance, to know how much of the same powder will charge any other peece of Ordinance

Question.

If a Saker of 4 inches diameter, require 5 pound of corne powder for her due loading, how much of the same like powder will charge a Cannon of 7 inches diameter?

Resolution.

The plaine rule of proportion cannot resolue this conclusion, except you multiply euery number cubically, and then the quotient will shew you your desire.

Example.

The cube of 4 is 64, and the cube of 7 is 343, which multiplied by the weight of the charge of powder due to load the lesser peece, ariseth 1615, which diuided by the cubicke number of the diameter of the lesser peece, yeeldes in the quotient 25 pound and almost ½ part of a pound: so much corne powder must a Cannon of 7 inches diameter haue to charge her with. And note, that for as much as now the shooting with Serpentine powder is not vsed, being of no great force, & the making of corne powder neuer better knowne, nor of more force than now it is made & daily vsed in shooting in great Ordinance, as also the great Ordinance now cast, not so fully fortified with metrall as they ought to be, being made more nimble and lighter than in times past, therfore the experienced Gunners doe obserue as a generall rule to abate ¼ part of the ordinarie charge of corne powder in all peeces aboue 6 inches bore.

How by knowing how much Serpentine powder will charge any peece of Ordinance, to know how much corne powder will do the like, or contrariwise by knowing how much corne powder will charge any peece of Ordinance, to know how much Serpentine powder will serue.

Question.

I demand how much corne powder will charge that Culuering that shoots 24 pound of Serpentine powder at a shoot?

Resolution.

You must note for a generall rule, that two parts of corne powder will doe as much as 3 parts of Serpentine powder: so that the proportion between the quantities or charges of these powders, is as 2 to 3, therefore I multiply 24 by 2, ariseth 48, which diuided by 3, my quotient is 16 pound so much corne powder wil charge the said Culuering. Or if you know how much corne powder will charge her, you may know how much Serpentine powder will serue, in multiplying 16 pound the due charge of corne powder, by 3. and diuiding the product by 2, your quotient is 24, as before. In this order you may doe the like by any other peece. And note that her due charge of corne powder, will lesse hurt the peece, than of Serpentine powder, for if Serpentine powder be rammed any thing hard, it is long a fieting. And a little heate long continued (which the Serpentine powder will doe) dangereth the peece more than a great heate presently gone, which effect corne powder works.

How

How by knowing how far your peece will shoot with her due charge in powder and shot, how to giue a neare estimate how far she will shoot with a charge more or lesse than her common charge.

Question.

Admit a Culuering shoote a bullet of 18 pound weight 900 paces, being charged with ¼ parts in powder of the bullets weight, I demand how far should the said peece shoot that bullet, if shee had beene charged with as much powder as the bullet weighed?

Resolution.

By the rule of proportion I finde she should shoot ¼ part further than shee did at the first shot, being charged with ¼ part of more powder, that is 1200 paces: yet it is knowne shee will not driue the bullet full out the ¼ part of this range further, although she will come very neare it, and the reason is, because the bullet flieth in a circular proportion more or lesse, a part of the range, after the insensible streight line or motion of the bullet be past, according to the degrees of rantion the peece is eleuated at. Also the concaue of the peece being filled vp with the powder, wadd and bullet, further than it ought to be, is a hinderance to the range of the bullet in proportion, according to that little quantitie of the concaue which the overplus of powder and wad filleth vp, which though it be but little in compation of the whole concauity to the range, yet it is a great hinderance in the bullets range, for that the bullet being so much neerer to the mouth, is driuen into the ayre before the powder be all fiered, and haue effected his force thereon: so that giuing the peece her bullets weight in corne powder, she

will shoote much further nor with an ordinarie charge, but it will both put the peece in danger of breaking, and those that are neare thereto in danger of their liues, if the peece be not all the better fortified with mettall.

How by knowing how much powder a few peeces of Ordinance haue spent, being but a few times discharged, to know how much powder a greater number of the same peeces will spend to be often discharged.

Question.

If 4 Cannons being twice discharged at any seruice, shoote 240 pound of powder, how much powder will charge 5 Cannons to shoote euery one 6 shots?

Resolution.

Worke by the double rule of proportion, saying, If 4 Cannons shoote 240 pound of powder, what will fiue Cannons? your quotient will be 300 pound: then say againe, If 2 times discharging yeeld 300 pound of powder, what 6 times? and your quotient being 900 pound weight, sheweth that so much powder is due to 5 Cannons, to shoote euery one 6 shots.

To know how much powder euery Cannon spent in the former conclusion at one shoote.

Question.

If 5 Cannons burne 900 pound weight of powder, being but 6 times discharged, how much powder did euery one shoote at one shoote?

Resolution.

Multiply 4 the number of peeces first propounded by 2, the times they were discharged, ariseth 8, by which di-

uide 140, the number of pounds in powder spent, the quotient is 30 pound, and so much powder did euery Cannon fire at one shoote. Or else you may multiply the other 5 Cannons by the times they were discharged, and diuiding that product by the powder spent, you shall haue 30 pound weight of powder in your quotient also.

How to know how much powder euery little caske or firken ought to containe, and how many of those caskes makes a Last of powder, and how many shots any quantity of powder will make for any peece of Ordinance.

Euery little caske or firken being empty, ought to weigh 12 pound, and being filled ought to hold an hundreth pound weight of powder: so that the full caske ought to containe 100 of Haberdepoize weight, & 24 of those caskes or firkins filled makes a Last of powder.

Question.

How many shots will one of those caskes filled with powder make to a Culuering that shootes 15 pound weight of corne powder at one shot?

Resolution.

Diuide the 100 pounds of powder in each firken by 15, the quotient will shew you that 100 weight of powder will be 6 shots to a Culuering that burnes 15 pound of powder at a shoote, and 10 pound to spare.

How by knowing how many shots a firken of powder will make for a Culuering, to know how many shots a Last of powder will make for a Cannon.

Question.

If a firken of powder of one hundreth weight charge a Culuering

Culuering 5 times, shooting 20 pound of powder at euery shot, how many of those shots will be in a Last of powder (containing 24 hundreth weight) to a Cannon that shoots 30 pound of powder at euery shot?

Resolution.

Reduce 24 hundreth weight into pounds, you haue 2400 pound; then say by the rule of 3 direct; If 100 pound weight of powder be but 5 shot, what will 2400? and you shall haue in the quotient 120 shot, for the said Culuering that shoots 20 pound weight at one shoote. And whereas the question sayes the Cannon shooteth 30 pound of powder at a shot, you must frame the backer rule of 3, and say, If 20 beare proportion to 120, what will 30? so multiplying 20 by 120, and diuiding by 30, the quotient is iust 80: so many shots of powder will be in a Last for any Cannon that shootes but 30 pound weight at a shot. The like is to be done with any other,

To know how many shots of powder will be in a Graund barrell for any peece of Artillery.

Question.

If an ordinarie Culuering shoot 15 pound weight of good corne powder at one shoote, how many times will a Graund barrell full of powder serue to charge her, the said barrell holding 300 weight?

Resolution.

Diuide 300 by 15, the quotient is 20, your desire: the proofe is easie; for multiplying 20 by 15, you haue 300 the number first propounded: the like is to be done if you would know how many shoots will be in a graund barrell, for any other peece of Ordinance, in diuiding the pounds of powder contained in the said Barrell by

by the number of pounds of powder due to charge the said peece.

To know Arithmetically what proportion of euery receit is to be taken to make perfect good powder, what quantitie so euer you would make at a time.

Question.

The best ordinary corne powder made in these daies, containeth 12 parts of M^t. 3 parts of cole, and 2 parts of Sulphur. The order how to compound and make the same is not peculiar to this Treatise, being meere Arithmeticall; I demand how many pound weight of euery sort is to be taken to make 1000 pound weight of powder?

Resolution.

Adde all the parts or pounds of the receits together, ariseth 17 pound for your diuisor. Then frame the golden rule, saying, If a mixture of 17 pound weight of powder, require 12 pound of the Salt-peter, what will 1000 pound weight? In multiplying and diuiding according to the rule, the quotient will be 705 pound, and $\frac{11}{17}$ pound a pound: so many pound of the M^t. is to be taken to make a thousand pound weight. Againe, say by the same rule, If that a mixture of 17 pound weight, do require 2 pound of Sulphur, what wil 1000? your quotient will shew you, that 117 pound & $\frac{11}{17}$ is to be taken. And lastly by the said rule say, If a mixture of 17 pound take 3 pound of Cole, what will 1000 pound take? and your quotient will tell you that 176 pound and $\frac{1}{17}$ parts is to be taken. The which 3 quotient numbers being all added together, will be iust 1000 pound weight, and so proues the worke to be truely done.

And note that the goodnes or badnes of powder may be known diuers waies, as by the colour, the taſt of the tongue, the quicke burning, &c. Alſo the brimſtone is that materiall ſubſtance that is moſt apt to kindle with any ſparke, the cole moſt fit to continue or maintaine the flame, and the Mr. being reſolued into a windie exhalation worketh the effect, as chiefe and principall of the three.

Before I frame theſe concluſions following, of the randon or range of the bullet, and the diuerſitie thereof, it is requiſite to make knowne to the Reader, how that diuers haue written, and ſome will vaunt that by the range or flight of the bullet out of any one peece of Ordinance knowne, they will or can tell the vtmoſt range of all other, thinking that the range of the bullet out of any one peece, ſhould be proportional to the bullet and charge of powder out of any other peece. Alſo ſome do affirm, that out of any one peece of Ordinance diſcharged with ſundry quantities of powder, they can tell the vtmoſt range of the bullets diſcharged; and their reaſon is, that the range of thoſe bullets ſhall bee proportionall to the weight of powder wherwith they were charged. And hereupon ſome haue giuen out rules which are falſe & full of errors: for the diuerſity of proportions cannot by the plaine rule of proportion be reſolued, as they affirme: but this may they do; Out of any one peece of Ordinance charged with one and the ſame like charge in powder & bullet, find by the rule of proportion, the neare difference or ranges of the bullets, the peece being mounted or diſmounted at any degree of randon; or by knowing how many paces, yards, feet, or other meaſure any peece will reach at point blanke, by knowing

knowing the point blanke and vtmoſt range of another peece of Ordinance, they may find the furtheſt range of the firſt. Or contrariwiſe, by knowing the vtmoſt range and point blanke of one peece, and the vtmoſt randon of another peece, they may find out the point blanke of that other peece, as by the rules following ſhall bee proued. And it is to be noted that any peece of Ordinance being mounted to the beſt of the randon or higheſt degree of the quadrant, the mouth and hollow cilinder of the ſaid peece, muſt be erected to 45 degrees, that is, at the 6 point of the skale in the quadrant (as the moſt part of quadrantes now are made:) but ſome peeces will ſhoote as far at the 5 point, or at 41, 42, or 43 degrees according as the winde is of calmeneſſe, for if any peece bee mounted higher than 45 degrees, ſhee ſhall ſhoote ſhorter in euery degree about the $\frac{1}{40}$ part of her vtmoſt range. And therefore to know how to worke theſe concluſions, you muſt buy an inſtrument Geometricall, or by ſome line of meaſure truely diuided, meaſure the diſtance from the peece to the place where the ſhot firſt fell or grazed, noting how many pearches, paces, yardes, or other meaſure that diſtance is; which knowne, diuide that diſtance by the degrees in the beſt of the randon, being 45, your quotient will tell you how many paces, yardes, feete, or other meaſure your peece will ſhoote further or ſhorter in mounting or diſmounting a degree: the which knowne, as I haue ſaid, by one truly meaſured, you may before you ſhoote, know very neare how far or ſhort your peece will ſhoote, at the raiſing or diſmounting of any degree, allowing one & the ſelfe like proportions in charging, both with powder, bullet and wad.

How by Arithmeticke skill you may know how with one and the selfe same like charge in powder and shot, how much farre or short, any peece of Ordinance will shoote, in mounting or dismounting of any degree; whereby you may know how far your peece will shoote at any degree of the randon, by knowing the distance she shoots at the vtmost grade.

Question.

If a Cannon at her vtmost randon (that is, at 45 degrees) carry the bullet 1440 paces from the peece, how farre shall the same peece shoote being dismounted but one degree?

Resolution.

To answer this or all such like, Her downe the numbers according to the rule of proportion, and multiplying and diuiding accordingly, I finde she shall shoot short in dismounting a degree, 32 paces, or 53 yeards, or 160 foote, which substracted from 1440, rests 1408 paces; so farre shall the Cannon shoote in dismounting her one degree of her furthest range. Or you may doe the like in framing the golden rule, saying: If 45 degrees range 1440 paces, what will one? and you shall haue 32 paces in your quotient as before.

How by knowing the distance to the marke, by the conclusion or rule before, you may know whether your peece will shoot short, or ouer the marke, or you may know how far it is from your platforme to any marke, within the reach of your peece, onely by knowing the vtmost range of your peece, and the degrees shee is eleuated at.

Question

Question.

Admit the ſame Cannon in the former concluſion, which ranged at the beſt of the randon 1440 paces, hauing the like charge in powder, ſhot and wad, is laid to ſhoote at a marke being mounted at 30. degrees. I demand how far it is from the peece to the ſaid marke, or how far the ſaid peece doth carry ſo mounted?

Reſolution.

To anſwer this, I multiply the paces my peece reacheth at the beſt of the randon, by thoſe degrees in the propoſition (to wit) 30 degrees, and there ariſeth 43200, which diuided by 45, my quotient is 960 paces, (that is, 40 paces leſſe than a mile) ſo farre will that peece ſhoot, being mounted at 30 degrees. And if you would know how much this is ſhort of the vtmoſt range, abate the ſame from the ſaid range, the remaine is your deſire. As 960 paces abated from 1440, reſts 480 paces, ſo much doth ſhee ſhoote ſhort of her beſt randon. In this order by 2 ſhoots knowne, you may know what any peece of Ordinance will doe being mounted aboue 10 degrees to the beſt of the randon, but vnder 10 degrees you ſhould erre ſomething in this practice, becauſe the range of the bullet flieth a great part of the way in an inſenſible ſtreight line, and the peece mouth eleuated aboue 10. degrees, ſhootes or driues the bullet in a more circular proportion.

The range or flight of the bullet by the draught in the next leafe may bee vnderſtood. And note that in ſeruice there is no peece of Ordinance light lie mounted aboue 15 or 20 degrees, except morter peeces, and ſuch like.

How to make a table of randons, or go very neare to know the true range of the bullet out of all sorts of peeces being mounted from degree to degree.

Many Authors haue taught how to make a table of randons, whereas some of them neuer shot in any peece of Ordinance in their liues. And for as much as I finde their writing and reasons differing, I thinke it will bee a very hard matter to make a perfect table of randons, except the same bee tried and experimented with some peece of Ordinance in some conuenient ground. I neuer heard nor read of any that hath as yet fully put the same in practice, the which would be much auailable to euery Gunner, to know what euery peece would doe at the mount of euery degree or point in the quadrant, the motion or range of the bullet being something variable at the mount of euery degree. You shall very neare find out the true range or randon of the bullet shot out of any peece of Ordinance, the peece mounted at any degree of randon, as thus:

Charge your peece with her due loading, in powder shot & wad, laying the peece at point blanke, which you may easily try, by putting the rule of the quadrant into the peece mouth, & coyning the peece at the breech, so as the plūmet may cut the quadrant in the line of leuel, as you see in the first figure hereafter drawn, that peece lieth point blanke: which done giue fire, & mark where the bullet first grazeth, after bring your peece to the same platforme, so as the wheeles and cariage stand neither higher nor lower than they did the first shoot: and being charged with one & the selfe like quantity in powder, bullet & wad as before, the peece being of like temper raise her mouth one degree, as the second figure

sheweth.

ſheweth: diſcharge her, and marke where the pellet falleth or grazeth firſt; then meaſure how far the firſt graze of the ſecond bullet is beyond the graze of the firſt bullet, ſo much will the peece conuey the bullet further at the mount of euery degree, or very neare thereto. But being mounted aboue 20 degrees, ſhe will ſhoote ſhorter & ſhorter, a litle at the mount of euery degree to the beſt of the randon, according to the height & circular motion of the bullet. If the peece be mounted to the beſt of the randon, the plummet will cut the 45 degree of the quadrant, as the 3 figure ſheweth. Or you may make a table of randons like the other, as thus: Meaſure the diſtance the peece conueyeth the bullet at the beſt of the randon, from which abate the diſtance the peece conueyeth her bullet at point blank, diuide the remaine by 45, the quotient wil ſhew you how far the ſhoot is carried at the mount of euery degree: or diuiding the ſaid remaine by ſo many degrees as you would eleuate your peece at, the quotient will likewiſe ſhew you how far the bullet doth range beyond point blank. *Example.*

If a Cannon at point blanke range 300 paces, and at the beſt of the randon ſhoote 1500 paces, how far ſhall ſhe ſhoote at the mount of one degree?

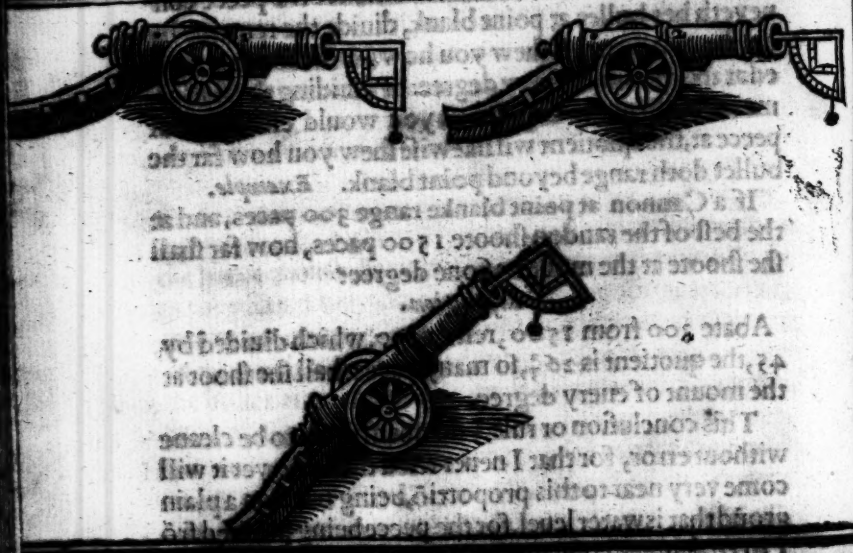
Reſolution.

Abate 300 from 1500, reſts 1200, which diuided by 45, the quotient is 26 $\frac{2}{3}$, ſo many paces ſhall ſhe ſhoot at the mount of euery degree.

This concluſion or rule, I do not affirme to be cleane without error, for that I neuer tried the ſame, yet it will come very near to this proportiõ, being tried on a plain groũd that is water leuel, for the peece being mounted frõ 11 to 10 degrees, conueyeth the bullet with litle bending

at

at the fall therof, and from 10 degrees to 20, as the motion of the bullet decreaseth: so it falleth more bowing than in the first 10 degrees. And mounted from 20 grades, to the best of the randon, conueyeth the bullet in a more circular course. And it is to be noted, that any peece of Ordinance hauing her due charge, will driue the bullet more ground mounted at 20 degrees, than from 20 grades to the best of the randon. And being truely loaden and discharged at the best of the randon, will driue the bullet 5 times the distance of her leuell range, or rather better.



w you may Arithmetically know how much wide, ouer, or ſhort, any peece of Ordinance will ſhoote from the marke, by knowing the diſtance to the marke, and how your peece is laid to ſhoote at the ſaid marke.

Queſtion.

If a Culuering or Cannon of 10 foote long, be ſhot t a marke 700 yardes from the peece, the mouth of the id peece planted an inch wide, how far ſhall the bullet ght wide of the marke?

Reſolution.

Reduce the meaſure of the length of the peece into ches, becauſe the denomination of wideneſſe is by in-es, and the peece of 10 foote length, will yeeld 120 ches. Likewiſe reduce the length from the peece to the arke into inches, you haue 25200 inches. Then by the le of proportion, ſay, if 120 inches ſhoot wide one inch, hat will 25200 inches? And in multiplying and diui-ng according to the rule, you ſhall finde in your quoti-t 210 inches, that is, 17 foote $\frac{1}{2}$: ſo much ſhall the 'er light wide of the marke. For this is a generall rule, t looke how many times the length of the cilinder or ncaue of the peece is to the marke, ſo many inches ll the peece ſhoote amiſſe, being laid ouer one inch, nder, or wide of the marke, if the winde doe not alter he like is to be done of any other.

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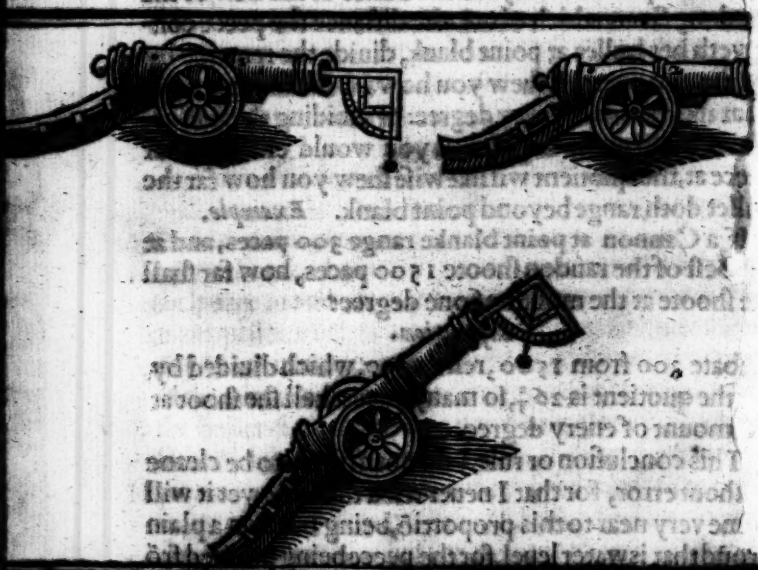

How

How you may Arithmetically know how much wide, ouer, or short, any peece of Ordinance will shoote from the marke, by knowing the distance to the marke, and how your peece is laid to shoote at the said marke.

Question.

If a Culuering or Cannon of 10 foote long, be shot at a marke 700 yardes from the peece, the mouth of the said peece planted an inch wide, how far shall the bullet light wide of the marke?

Resolution.

Reduce the measure of the length of the peece into inches, because the denomination of wideneſſe is by inches, and the peece of 10 foote length, will yeeld 120 inches. Likewiſe reduce the length from the peece to the marke into inches, you haue 25200 inches. Then by the rule of proportion, ſay, if 120 inches ſhoot wide one inch, what will 25200 inches? And in multiplying and diuiding according to the rule, you ſhall finde in your quotient 210 inches, that is, 17 foote $\frac{1}{2}$: ſo much ſhall the bullet light wide of the marke. For this is a generall rule, that looke how many times the length of the cilinder or concaue of the peece is to the marke, ſo many inches ſhall the peece ſhoote amiſſe, being laid ouer one inch, or vnder, or wide of the marke, if the winde doe not alter it. The like is to be done of any other.

A remedy to lay your peece ſtraight, if ſhe lie either ouer, vnder, or wide of the marke.

Let a plumbe line fall perpendicularly ouer the middle part of the breech of the peece, and with a hand-ſpike

or leuer, winde the carriage of the peece to and fro till you eſpie the middle part of the mettall at the mouth of the peece, and the ſaid line diuide the marke in 2 equall parts: ſo ſhall you make a ſtreight ſhot, giuing the peece her true diſparture and length.

Another way.

Or you may take the true diameter of the concaue at the mouth of the peece, laying an inch rule to the ſame, diuide the ſaid diameter in 2 equall parts; to the point of which diuiſion being the center of the cilinder of the peece, let a threed and plummet fall, or elſe erect a ſquire, ſo as the containing angle touch the center or middle point of the diameter, by the edge of which rule or ſquire draw a line with the point of your knife, from the height of the mettall at the mouth: that line would croſſe in the center if it were continued, and it is a perpendicular or plumbe line to the other; by which line or ſtrike ſo drawne, with a little peece of ſoft waxe, ſet vp a ſtraight ſtraw, to reach a little aboue the mettall. And knowing likewiſe the middle mettall at the breech of the peece, it is an eaſie matter to make a ſtraight ſhot, if the 2 ſights (to wit) the ſight at the breech and mouth bee laid ſo as they diuide the ſaid marke in 2 parts: for this is generall, that any three things that the eye can comprehend at once, being equall with the eye, are in a ſtraight line from the eye, whether the ſame bee at aſcent or deſcent.

The line or ſtrike thus drawne at the mouth of the peece, will ſhew you preſently where and how to ſet vp your diſparture of your peece at any occaſion.

In ſhooting without diſparting your peece at any marke within point blanke, to know how farre the bullet will flie ouer the marke by knowing the diſtance to the marke.

Queſtion.

A Cannon or Culuering of 12 foote in length, hauing three inches more mettall at the breech on each ſide than at the mouth, ſhooting at a marke ſuppoſed to bee within the leuell range, and 600 yards from the mouth of the peece, being ſhot without her diſparture, how much ſhall the ſhot flie ouer the marke?

Reſolution.

It is a generall rule, that looke how much the peece is thicker of mettall, in any one ſide at the breech, than at the thickeſt part at the mouth, as alſo looke how many times the length of the peece is to the marke, ſo many times that ouerplus of thickneſſe ſhall the bullet flie ouer the marke, being no higher than the peece, and the ſaid peece diſcharged without her diſparture.

Example.

Diuide 600 yardes (being the diſtance from the peece to the marke) by 4, (the length of the peece) your quotient is 150, which multiplyed by 3 inches the ouerplus of mettall, ariſeth 450 inches: ſo much ſhall the bullet flie ouer that marke, the marke being placed on the ſide of a hill or bearing banke, and within the leuell range of the peece.

In like manner ſhooting at any marke within

$\frac{1}{3}$ the vtmoſt range of the peece, and not diſparting your peece, you ſhall ouer-ſhoot ſomething, giuing the peece her due length and due loading.

How you may lay your peece point blanke without inſtrument.

If you bring the height of the mettall at the mouth of the peece, and the height of the mettall at the breech, equall with the horiſon, the hollow cilinder of the peece will lie point blanke.

How you may Arithmetically diſpart any peece of Ordinance truely diuers waies.

If you meaſure with a paire of Callapers the greateſt height of mettall at the mouth of the peece, and likewiſe at the breech, abating the leſſe out of the greater, $\frac{1}{3}$ the remainder is the iuſt diſparture.

Example.

A Culuering that is 19 inches high at the greateſt part of mettall in the breech, will bee 13 inches high at the greateſt part of mettall at the mouth: which 13 inches abated from 19, reſts 6, which diuided in 2 equall parts, the quotient being 3 inches ſheweth the true diſparture of that Culuering.

Another way to diſpart any peece without Callapers.

Take a line and meaſure the greateſt circumference of mettall in the breech, then multiply that meaſure by 7, diuiding the product by 22, the quotient is the diameter, or height of the circumference. Likewiſe meaſure the greateſt circumference of mettall at the mouth, multiplying that meaſure by 7, diuide by 22 as before, the quotient will ſhew the diameter of the mettall at the mouth,

mouth: ſubſtract that diameter laſt found, from the diameter at the breech ½ the remaine is the true diſparture.

Example.

A Culuering whoſe greateſt circumference of mettall at the breech containeth 66 inches, and at the mouth 44 inches, I demand how high is the diameter of the mettall both at the breech and mouth, as alſo what is the true diſparture of that peece?

Reſolution.

Multiply 66 by 7, ariſeth 462, diuide by 22, the quotient is 21, the height of the mettall at the breech: likewiſe multiply 44 by 7, you haue 308, diuide by 22, the quotient is 14, the height of the mettall at the mouth, which 14 abated from 21 reſts 7, the which 7 diuided in 2 equall parts, yeelds 3 inches ½ for a part, the true diſparture of that Culuering.

This is one of the principalleſt points belonging to a Gunner, to know truely how to bring the concaue of the mettall of his peece euen. Diuers other waies there be to doe the ſame: As for chambred peeces, there is no perfect or generall rule, but is to bee conſidered according to the chamber or concaue of the peece. Euery reaſonable Gunner may iudge in that caſe.

How by Arithmeticall skill you may mount any great peece of Ordinance, by an inch rule vnto 10 degrees of the quadrant, if you want a quadrant or other inſtrument.

Firſt you muſt meaſure the iuſt length of the Cannon or bore of the peece: reduce that meaſure into inches, and double the ſame: afterwards multiply the number of inches ſo doubled by 22, and diuide by 7, and note what

the quotient number is, which quotient diuided by 360 the degrees contained in the whole circumference of euery circle, the laſt quotient number will ſhew you the number of inches, and parts of an inch, that will make a degree in the quadrant for that peece.

Example.

Admit there is a Saker or Fawcon, whoſe concaue or bore containeth iuſt 7 foote in length, and that you deſire to know what parts of an inch rule will mount her to one degree of the quadrant, you muſt reduce 7 foote into inches, and you haue 84 inches, that 84 doubled is 168, the which multiplied by 22 ariſeth 3696, the which diuided by 7, the quotient will bee 5283; that quotient number being diuided againe by 360, will yeeld 1 $\frac{7}{11}$ (that is) one inch and $\frac{1}{5}$, wanting $\frac{4}{11}$ part of an inch. So I affirme that any peece of Ordinance whoſe chaſe or bore is but 7 foote long, being mounted by an inch rule one inch and $\frac{7}{11}$ parts, that peece ſhall lie iuſt the height ſhe would haue done if you would haue mounted her one degree of the quadrant. The like order is to bee obſerued in mounting any other peece of Ordinance by an inch rule, of what length ſoeuer. And note that in mounting any other peece of Ordinance, to any degree of the quadrant, by a Geometricall quadrant, you muſt put the rule of the quadrant into the peece mouth, lifting the peece vp or downe with a leauer or hand-ſpike towards the breech, till the plummet cut iuſt vpon that degree of the quadrant you deſire.

But to mount her by an inch, you muſt place the rule vpon the higheſt part of the mettall at the breech of the peece, coyning the peece vp or downe, till through the ſight or ſlit in your rule (be lifted to that part or diuiſion

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in your rule that answereth the degrees you desire) you espie the Carnoize or highest part of the mettall at the mouth of the peece, and the marke, all 3 in a straight line.

If you would mount the same peece to 2 degrees of the quadrant by an inch rule, you must multiply the measure in your rule last found, being 1 inch $\frac{7}{15}$ parts by 2, in the order of fractions, and you shall haue $\frac{44}{15}$, the which 44 being the numerator of the fraction diuided by 15 the denominator, the quotient being 2 inches $\frac{14}{15}$ is your desire: so may you affirme that 3 inches by the rule wanting $\frac{1}{15}$ part of an inch, will make 2 degrees by the quadrant.

And note, that looke how much you would haue your peece mounted by an inch rule for to answer any number of degrees vnder 10, either multiply that number by the number of inches and parts of an inch, that makes a degree of the quadrant, or else working as you did the first conclusion, multiplying the first product by the number of inches desired, and diuiding that product by the numbers afore mentioned, your last quotient will resolue you of your desire.

Example.

I demand how much the peece afore mentioned should be eleuated by an inch rule, to answer to 8 degrees of the quadrant?

Resolution.

Reduce the length of the bore of the peece into inches, as afore is shewed, doubling that measure, and it makes 168, as you see in the 1 conclusiō: which 168 inches multiplied by 22, yeeldeth 3696 inches, the which product afterwards multiplied by 8, ariseth 29568, which summe diuided by 7, the quotient is 4224: the same diuided by

by 360, yeelds in the quotient 11 inches $\frac{11}{15}$ parts of an inch, ſo many inches and parts of an inch muſt the ſame peece be eleuated to with an inch rule, to anſwer to 8 degrees of the quadrant, as by triall you may finde.

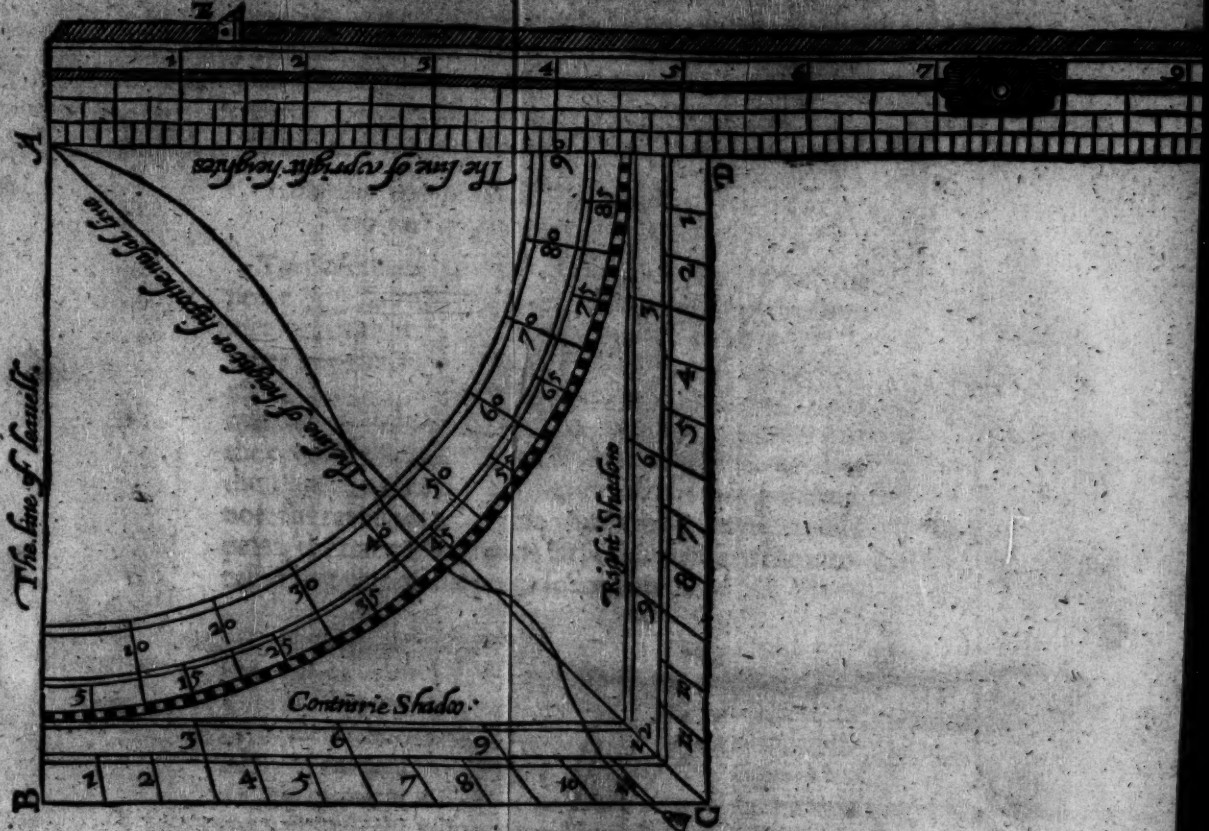
How by Arithmeticke skill you may know the true thickneſſe of mettall in any part of any peece of Ordinance.

Take a paire of callapers, and meaſure the height of the out-ſide of the mettall in that place of the peece whereas you deſire to know the thickneſſe of the mettall, then with an inch rule, or elſe a paire of ſtreight compaſſes, meaſure the diameter of the bore, or concaue of the peece, abating the height of the ſaid diameter from the height of the whole thicknes of that part of the peece ſo meaſured. And note the remainder, the which diuide in 2 equall parts, and the one of thoſe parts is the iuſt meaſure of the thickneſſe of the mettall in that part of the peece.

Example.

I prooued this concluſion with a Culuering, whoſe bore or concauity at the mouth was 5 inches $\frac{1}{2}$ height, & I found that the thicknes or height of the whole circumference of the ſaid peece at the touch-hole, was 16 inches $\frac{1}{2}$, from the wich I abated 5 inches $\frac{1}{2}$ (fraction wiſe) reſts 10 inches $\frac{1}{2}$ parts of an inch; that diuided in 2 equal parts, the quotient is 5 inches, and $\frac{1}{12}$ or 5 inches $\frac{5}{12}$ wanting the $\frac{1}{12}$ part of halfe an inch, ſo thicke was the mettall of that Culuering at the touch-hole.

Likewiſe I ſearched for the thickneſſe of mettall in the ſame peece at the end of the trunions, and I found that the thicknes or height of the ſuperficies of all the mettall there



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ing 4 inches, fhewed the true thickneſſe of metall

there contained 13 inches, from which I abated the diameter or concaue at the mouth, being 5 ½ inches, rested 7 ½, which diuided in 2 equall parts, the quotient being 3 inches ¾ shewed the true thicknes of the mettall at the trunions. In this order you may finde the true thicknesse of mettall in any part of any peece of Ordinance.

Another way to know the thicknesse of mettall in any part of any peece of Artillerie.

Take a letherne girdle, and gird about that part of the peece you desire the thicknesse of mettall, lay the same measure to an inch rule, and note how many inches or other measure the same containeth: then multiply that measure by 7, and diuiding the product by 22, your quotient is the true measure of the whole thicknesse of the peece in that place. Then substracting the diameter of the bore or concauity of the peece from that quotient, note the remainder. Diuide that remaine in two equall parts, the one of those parts is the thicknesse of the mettall in that part of the peece so measured.

Example.

I prooued this conclusion with a demy Cannon of sixe inches diameter, in girding the same about with a line hard behind the trunions, and laying the same to an inch rule, it contained 44 inches, which summe multiplied by 7, amounted to 308 inches: that sum diuided by 22, my quotient was iust 14. And so many inches was the height of the whole mettall in that part of the peece, out of which quotient I did abate the diameter or bore of the peece, being 6 inches, and the remaine was 8 inches, which diuided in 2 equall parts, my quotient being 4 inches, shewed the true thicknesse of mettall

in that part of the peece, being hard behind the trunions towards the breech.

And it is to be noted, that euery peece of Ordinance if it be truly fortified with mettall, ought to containe as much mettall in thicknesse round about, so farre as the chamber where the powder and wad lyeth, as the bullet is in height.

How to make a good shot in a peece that is not truly bored: or to know how much any peece will shoote amisse, that is thicker of mettall on the one side than on the other, if you know the distance to the marke.

Question.

A certaine Gunner hauing shot diuers times in a Cannon at a marke supposed to be 500 paces from the peece, findeth shee shooteth still towards the right hand, and searching whether the fault were in himselfe, or some impediment in the peece, he findeth that the peece is 2 inches thicker of mettall on the right side than on the left. And therfore requesteth how to lay the concaue of the peece (being 9 foote in length) equall with the marke, so as he may make a straight shot.

Resolution.

To doe this or the like, there is a generall rule, that looke how oftentimes the length of the cilinder or concaue of the peece is to the marke, which is easily done by diuiding the distance to the marke, by the length of the concaue of the said peece. And knowing likewise how much the one side of the peece is thicker than the other, the one halfe of that ouerplus being multiplied by the quotient first found, the product will shew you how

much the peece ſhooteth wide of the marke. And this is a generall rule: that looke which ſide of the peece is thickeſt of mettall, towards that ſide ſhall the bullet fall, for that the thinner ſide is more ſmart, and the thicke ſide more dull in heating.

Example.

The Cannon in this concluſion, is ſaid to be 2 inches thicker of mettall more in thickneſſe on the right ſide than on the left. And the diſtance to the marke is ſuppoſed to be 500 paces, (that is, 2500 feete,) the which diuided by 9 feete, being the length of the hollow cilinder of the Cannon, yeeldeth in the quotient 277 feete $\frac{7}{9}$, the which multiplied by $\frac{1}{2}$ the ſuperfluitie of the mettall being one inch, makes 272 feete $\frac{7}{9}$ ſtill, and ſo much wide of the marke ſhould the ſaid peece haue ſhot at ſuch a diſtance, although ſhee had beene laid full againſt the mids thereof.

How to remedie your peece being thicker of mettall in one part than another to make her ſhoote ſtreight.

You muſt firſt ſearch your peece with an inſtrument, to know which is the thicker ſide, then diuide the ouerplus of mettall in 2 parts, ſetting the diſparture of your peece one of thoſe parts towards the thickeſt ſide of the peece mouth, and bringing the midle part of mettall at the taile of your peece, that diſparture and the midle of the marke, all in one ſtreight line, giue fire and you ſhall make a ſtreight ſhot. But beware of ouercharging of ſuch peeces, for they are dangerous.

If the thickeſt part of the mettall bee aboue, then you ought to make your diſparture one inch more: if vnder (I meane towards the carriage) an inch leſſe.

To know the different forest of any two like peeces of Ordinance planted against an object, the one being further off from the said object than the other.

Question.

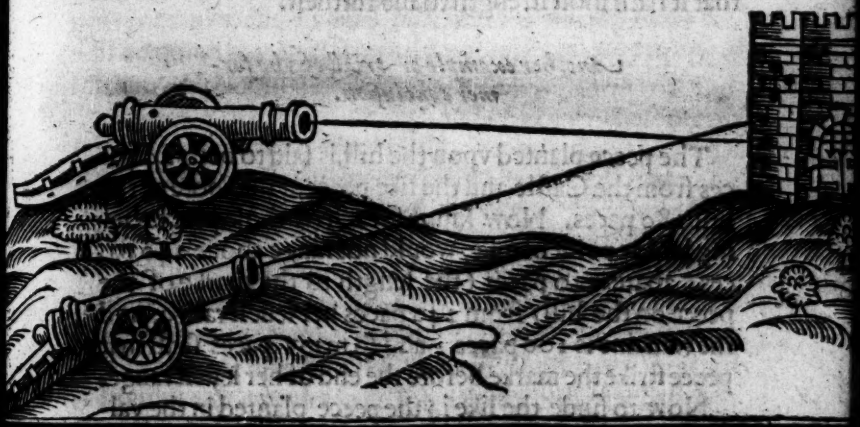
Admit there is a Castle or Fort to be battered, being situate vpon a hill, which hill is 50 paces in height, and that 140 paces from the said Castle, there is another hill, of equall height to that hill whereon the Castle is built, and Ordinance planted thereon to beat or batter the Castle wall, and in the valley at the foote of the said hill 180 paces off from the Castle hill, there is Ordinance planted, and mounted at 20 degrees, to shoote and beat down the said Castle: I would know whether the Ordinance in the valley being 180 paces distance from the Castle, and mounted at 20 degrees, or the Ordinance on the height of the hill, lying leuell to shoote a little aboue the base of the wall, being distant there from 140 paces, shall worke the greatest effect in battering downe the said Castle wall, the said peeces being of like length and height, and hauing like charge in powder and bullet?

Resolution.

To resolue this or the like, a man would thinke that the peece planted on the height of the hill, lying leuell to shoote a little aboue the ground-worke of the Castle, would batter forest, because she is neareſt: yet by experience we finde the contrary, for the Castle being a great way within the reach of both the peeces, that peece shall not onely shoote much further that is any thing elevated, but also pierce much forer, by so much as she is able to ouer shoot the other selfe like peece that lyeth leuell: albeit

albeit the ſaid peece ſo eleuated, bee planted furtheſt off from the ſaid reſiſting obiect: for euery Gunner knoweth, and reaſon and experience doth teach euery reaſonable man, that no peece of Artillery will ſhoot ſo far at point blanke, as when the ſame is eleuated at any number of degrees, becauſe the bullet being ponderous, flieth more heauily and ſooner declineth, being ſhot out of any peece lying leuell, than out of any ſuch like peece mounted at any degree of the randon. So that of force it muſt needs follow, that the peece planted in the valley 180 paces off from the Caſtle, ſhall pierce and batter a great deale ſorer than the like peece planted on the height of the hill being but 140 paces from it.

Example.



Example.

Suppose a Cannon or Culuering at point blanke shoot 240 paces, and being mounted at one degree out-shoote the same 30 paces, what will the said peece doe being mounted 20 degrees?

By proportion I find, that if at the mount of one degree, any bullet range 30 paces beyond the leuell range, that at 20 degrees it shall out-flie the same 600 paces: albeit the said bullet range not in euery degree a iust like number of paces, yet the proportion will be very neare thereto. And becausse the peece at the foote of the hill is said to bee 40 paces further from the Castle, than the like peece planted on the height of the hill, I abate 40 out of 600, rests 560 paces: so farre would the peece in the valley out-shoote the other like peece on the hill; so that it must needs follow, her bullet shall pierce soreſt, for that it hath most strength to flie furthest.

Another example or triall of the former conclusion.

The peece planted vpon the hill, is said to bee 140 paces from the Castle, and the like peece at the foote of the hill 180 paces. Now suppose each of those peeces being laid at point blanke, would not range aboue 240 paces, abate 140 paces (the length to the marke of the peece on the hill) from 240 paces her leuell range, and the remaine is 100 paces; and so many paces shall that peece strike the marke before the end of her leuell range.

Now to finde the like in the peece planted in the valley 180 paces from the Castle, mounted at 20 degrees,

I finde by the concluſion afore ſet downe, that ſhee ſhall out-ſhoote the other 600 paces: ſo that abating the diſtance from the peece to the Caſtle, being 180 paces from 840 paces, her whole range mounted at thoſe degrees, there remaines 660 paces. And foraſmuch as the ſaid peece eleuated at 20 grades, doth ſtrike the marke 660 paces before the full end of the range of her bullet, it muſt of force pierce or batter ſorer than the other peece whoſe bullet beates the marke but 140 paces before the full end of his range.

How you may hauing diuers kindes of Ordinance to batter the wals of any Towne or Caſtle, &c. tell preſently how much powder will loade all thoſe Ordinance one or many times.

Queſtion.

There is a Caſtle beſieged, and to batter the ſame there is appointed 4 Cannons, 6 demy Cannons, 6 Culuerings, 8 demy Culuerings, and 5 Sakers: theſe peeces are charged euery time with corne powder, the whole Cannons ſhoote at euery ſhot 32 pound of powder a peece, the demy Cannons 18 pound, the whole Culuering 16 pound, the demy Culuering 12 pound, and the Sakers 6 pound a peece. All which peeces being 10 times diſcharged, did make a breach ſufficient for 9 or 10 men to enter in by ranke (a breach of ſuch a widenes is thought ſufficient to bee aſſaultable,) I demand how much powder was ſpent before the breach was made?

Reſolution.

Resolution.

To answer this demand, I multiply the number of euery sort of peeces, by the weight in powder that one of them shootes, and the product sheweth me how much powder euery sort of the said peeces did spend at one bout: then I adde euery number together, and the totall of that addition sheweth mee how much powder will loade all those peeces one time, which addition multiplied by 10, being the times they were supposed to bee discharged, the product sheweth the iust quantitie of corne powder occupied at the said siege by the great Ordinance.

Example.

I multiply 32 pound the weight of powder due to loade euery Cannon by 4 the number of Cannons, ariseth 128. Likewise 18 pound of powder being the duty of euery demy Cannon multiplied by 6 the number of the same peeces, ariseth 108, and 16 pound of corne powder being the duety of euery Culuering multiplied by 6 the number of those peeces, is 96. And 12 pound of powder being the due loading of euery demy Culuering multiplied by 8. the number of the same is 96. And lastly, 6 pound of powder the duety of euery Saker, multiplied by 5 the number of that sort of peeces, is 30. These summes or additions put together makes 458 pound weight of powder: and so much will discharge all those peeces one time; the which summe multiplied by 10, is 4580 pound of powder, that is, two Last of powder wanting 220 pound. In this order if you haue 20 Last of powder, by knowing the number of euery sort of seuerall Ordinance, you may presently know

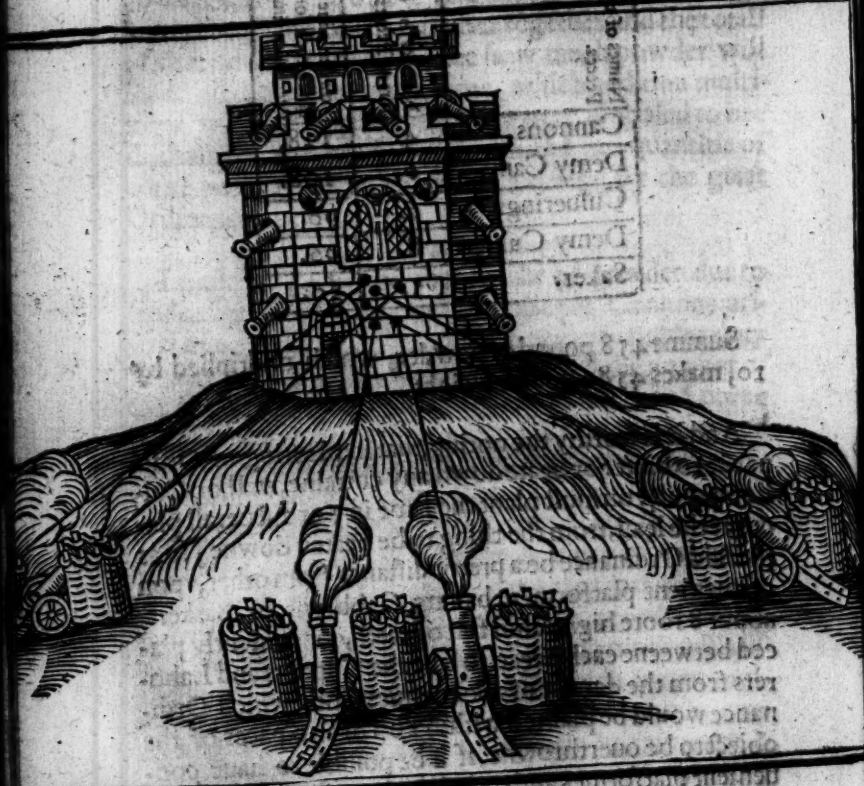
know how many shots, or how many times the said powder will loade all the said Ordinance, as this Table sheweth.

Names of the Peeces.	Number of each sort of Peeces.	Powder due to loade each sort of Peeces one time.
Cannons.	4.	128.
Demy Can.	6.	108.
Culuerings.	6.	96.
Demy Culuer.	8.	96.
Saker.	5.	30.

Summe 458 pound of powder, which multiplied by 10, makes 4580 pound weight.

And it is worthy the noting, that in planting of Ordinance to batter or beate downe any curtaine, wall, or Cullion point, you must plant the same in 3 or 2 seuerall places at the least, from the thing to be beaten downe; so as the said Ordinance be a pretty distance from other, vpon conuenient platformes, hauing Gabbions or Baskets, about 8 foote high, ramd full of earth, conueniently placed betweene each peece, to saue the Gunners and Laborers from the danger of the enemies shot: which Ordinance would be planted within 200 or 240 paces of the obiect to be ouerthrowne, if it be possible to haue conuenient platformes and to bring them so nigh the said obiect. The which Ordinance, if so you haue made 3

mounts or platformes, the Ordinance from the 2 ſide mounts doth come or cut out that which the Ordinance from the middle mount doth batter or pierce, or ſhake, as this draught here drawne ſheweth.



The

The best shooting to batter downe the broad side or curtaine of any wall, is to leuell something vnder the middle part of the wall, and after to shoot 2 or 3 foote higher: for the lower part being beaten downe, the height or vpper part of the said wall must fall of necessitie. And a speciall regard must be had to giue fire from each platforme or mount at one instant, for that the bullets beating all together, doe more shake and batter the said wall, than lighting now one and then another.

In the figure or draught which I haue drawne shewing how Ordinance may be planted to ding downe or batter the broad side or curtaine of any wall, Castle or Fort, the middle Ordinance placed on the middle mount or platforme, directly against the obiect to bee beaten downe, are called the pearcers, and are onely to shake and beate the wall, and the Ordinance on the two other side mounts, or platformes shooting something slanting, are to coyne or cut out that which the Ordinance from the middle platforme doth shake or loose. The Baskets ramd full of earth, being placed betweene each peece of Ordinance are to defend the Gunners and Labourers from hurt of them that are besieged, as afore I haue said.

And furrher it is to bee noted, that to batter the coyne or cullion point of any wall, two places is sufficient to plant your Ordinance in. Also you may batter and beate downe the wall of a Towne or Castle as well by night as day, so as the enemie shall haue no time to build vp in the night that which was dung downe in the day, as thus: Lay your peece or peeces, to the marke in the day light, and note well what degree of the quadrant shee lieth at, which is

ſoone done in putting the rule of your quadrant into the peece mouth, ſo laid againſt the marke, letting a line and plummet fall to the ground from the ſaid point of your quadrant, and at the lighting of the plummet on the ground, there driue in a ſtake or wooden pin; and letting a plumbe line fall likewiſe from the middle part of the taile or breech of your peece to the ground, driue therein another ſtake into the ground, then ſtretch a line from the ſaid 2 pinnes, ſo as the ends of the ſaid line may reach 2 or 3 yards further than the pinnes at each end. And there make them faſt in driuing a pin of Wood or Iron into the ground at each end, then bringing your peece or peeces to lie ſtraight aboue the ſaid line or lines ſo drawne (which is eaſily done hauing a lanterne with a cloſe couer) you may both charge and recharge and ſhoote as well by night as day, according to your deſire.

How you may know the true weight of any number of ſhot, for ſeuerall peeces of Ordinance, how many ſoeuer they be, and how many Tun weighe they doe all weigh.

Queſtion.

Suppoſe a Ship is loaden with Bullets to be carried to the ſiege of a Towne, &c. in which ſhip is 500 ſhot for whole Cannons, 800 demy Cannon ſhot, 900 Culuering ſhot, 1000 demy Culuering ſhot, 1100 Saker ſhot, 1200 Minion ſhot, and 1400 Fawcon ſhot, the queſtion is to know the true weight of all the ſhot, and how many Tun they doe all weigh.

Reſolution.

Reſolution.

In the beginning of this Treatiſe I ſhewed how to find out the weight of any vnknowne bullet, by the weight of a knowne bullet of the like mettall, ſo that multiplying the number of euery ſeuerall ſort by the weight that one of them weigheth, and adding all the products into one ſumme, and then dividing that totall by 2240 pound, which is the pounds in a Tun, the quotient will ſhew you how many Tun all thoſe bullets weigheth.

Example.

A demie Cannon ſhot weigh 60 pound a peece, by which I multiply 500 (the number of that kinde of bullet) ſo ariſeth 30000 pound weight, and then there is 800 demie Cannon ſhot of 32 pound weight a peece, which multiplied as before, makes 25600 pound weight. And then there is 900 Culuering ſhot of 16 pound weight a peece, which makes 14400 pound weight. And then 1000 demie Culuering ſhot of 10 pound weight a peece, which makes 10000 pound weight. And then 1100 Saker ſhot of 5 pound weight a peece, which makes 5500 pound weight. And then 1200 Minion ſhot of 3 pound weight a peece, which makes 3600 pound. And laſtly 1400 Fawcon ſhot of 2 pound weight a peece, which makes 2800 pound weight. All theſe ſummes added together makes 91900 pound weight, which diuided by 2240, yeelds in the quotient 41 Tun, and 60 pound weight remaining.

In this order you may know how many Tun weight any number of ſhot weigheth, ſo that knowing how many Tun any ſhip is of burthen, you may eaſily know how many ſhot will load the ſaid ſhip.

How any Gunner or Gun-founder may by Arithmetick tell, whether the trunions of the peece be placed rightly on the peece or not.

Measure the length of the bore of the peece, from the mouth to the breech, diuide that measure by 7, and multiply the summe that commeth in the quotient by 3, the product will shew you how many inches or other measure the trunions ought to stand from the end of the lowest part of the concauitie of the said peece at the breech.

And note that the trunions ought so to be placed, as parts of the circumference of the peece may be seene in that place whereas the trunions are set.

Example.

A demi the cilinder or concaue of a Cannon, or other peece of Ordinance be 10 foot 2 long, I demand where the trunions of the said peece ought to stand?

Answer.

Reduce the length of the concaue of the peece into inches, you haue 126 inches, the which diuided by 7, the quotient is 18, that multiplied by 3, makes 54 inches, or 4 foot $\frac{1}{2}$, so farre ought the trunions to bee placed from the breech or lowest part of the hollow concauitie of the said peece.

Another way.

Or multiplying the length of the concaue of the peece by three, and diuiding the product by 7, the quotient will shew the true place, how farre the trunions

ought

ought to ſtand from the loweſt part of the bore or concauity of the peece.

Example.

126 inches the length of the concaue of the peece, multiplied by 3, makes 378 inches, which number diuided by 70, the quotient is 5 4 inches as before.

And note that the trunions of euery peece were inuented to hold the peece vp in her cariage, to moue her vp and downe to make a perfect ſhot, and to hold her faſt in her cariage after ſhe is diſcharged, for if the trunions be placed too neere the mouth, the peece will be too heauy towards the breech, ſo as the Gunner appointed to ſerue with her, ſhall haue much adoe to raiſe her, to coyne her vp or downe, or being placed too neere the breech, the contrary will happen.

How you may know what empty caske is to be prouided to beare or carry ouer any peece of Ordinance ouer any riuer, if boates or other prouiſion cannot be gotten.

It is thought ſufficient that 5 Tun of empty caske will ſwimme and carry ouer a Cannon of 8 or 9000 pound weight, a Tun will carry ouer a demy Cannon, 3 Tun a Culuering, and a Tun a Saker, accounting all prouiſions to be made faſt thereto, as planks, ropes, &c. ſo that knowing what number of Ordinance is to be ferried or carried ouer any riuer, adding all their weights into one ſumme, by framing the Golden rule, you may preſently know what empty caske is to bee prouided to ferry ouer all the ſaid Ordinance at one inſtant.

Example.

Exemple.

If a Cannon of 8000 weight require 5 Tun of empty caske, how much emptie caske is to be prouided to carry ouer so many Ordinance as is supposed to be 100000 weight?

Resolution.

I multiply 100000 by 5, so ariseth 500000, the which being diuided by 8000, the quotient is 62 ½, so many Tun of emptie caske is to be prouided to carry ouer so many Ordinance as weigheth 100000 pound weight. The which empty caske made fast head to head arow on each side, by such as haue skill in such seruices, and planked aboue, would serue for a bridge to carry ouer a whole Army with all prouisions thereto belonging.

All which necessaries in time of seruice, & many more, belongeth to the Master of the Ordinance his office, to haue in readinesse, as also to bee prouided of Trunkes, Arrowes, Balls, and all kinde of fire-workes, wet or drie, and the receits for making thereof. As also engines for mounting or dismounting of Ordinance, Wheeles, Axeltrees, Bullets, Powder, Ladles, Sponges, Ropes, Shouels, Anchors, &c. Also it is the duety of the Master of the Ordinance, the Master Gunner, and euery chiefe officer or quarter Master vnder them, to be expert in the Art of Gunnerie, the better to teach and instruct their inferiours, the which without some practice in Arithmeticke and Geometry they cannot well accomplish. They ought to haue some light in the Mathematicalls, the better to teach and instruct such as would shoote at all randons, to know what Ordinance is conuenient for an Army, or to batter or beate downe the walls of any Towne or Castle, to know what powder and shot is to be

prouided

prouided for that or ſuch like purpoſe, what cariage horſes, labourers and other neceſſaries is to bee allowed for the ſame. They ought to practiſe all Geometricall inſtruments, for the meaſuring of heights, lengths, breadths, depths, &c. To practiſe how to conueigh mines vnder the ground, and how the ſame ſhould bee truely wrought, to blow vp any Towre, Caſtle, &c. To know what length the mine will containe with all his windings to and fro to the place appointed. To haue skill, in the handling of all engines and inuentions belonging to the Ordinance. To appoint to euery peece of Ordinance in time of ſeruice, Gunners that know perfectly how to manage their peeces, to charge, ſhoot, cleanſe, ſcoure, wad and ram the ſame, and what labourers are to attend thereon. To know in euery platforme appointed, how to place the baskets or gabbions, and what proportion of wideneſſe, height, or thickneſſe they ought to containe: and that the loopes haue their due proportion of wideneſſe. To ſee that euery Gunner be able to diſcharge his dutie, and not for fauour or affection to preferre ſuch as can ſay moſt, and doe leaſt: but that euery man bee preferred to place of credite, and eſteemed according to his honeſt behauiour and skill in this ſingular Art. That none bee permitted to the profeſſion of a Gunner, but that he be firſt truely inſtructed in the principles of the Art, by ſuch as haue skill therein. And not to make or ſuffer euery tagge and ragge to bee a Gunner, as is too much vſed in theſe dayes in Townes of garriſon, who was neuer practiſed in the Art, nor hath diſcretion nor deſire to practiſe therein: a great number of ſuch haue but onely the bare name of a Gunner, although their ſtanding hath beene of long time: for as a great

great many of Marriners haue saild 7 or 8 yeeres, and yet farre from a Nauigator, so a great many such haue continued in pay a large prentise-hood, and yet farre from a good Gunner. Such in time of seruice would worke as the builders did at the Tower of Babell, when one cald for one thing, he had deliuered a contrary thing. In seruice the Prince by such is not truely serued, the Art lesse esteemed, and themselues discredited.

The Art is like to a circle without end, or like to a Labyrinth, wherein a man being well entred in, knoweth not how to get out againe, and therefore it must bee exercise and industrie that must make a perfect Gunner. Many things here could I write pertaining to the durty of a Gunner, and euery officer pertaining to the Ordinance, but for as much as the same is not peculiar to this Arithmeticall Treatise, and sufficiently handled by other Authors, I omit.

How to know the true time that any quantitie of Gunmatch being fired, shall burne, to doe an exploit at any time desired.

Take common match, and rub or beat the same a little against some post or stoole to soften it, and then either dip the same in salt-peter water, and drie it againe in the sun, or else rub it in a little powder and brimstone beaten very small and made liquid with a little Aqua vitæ, and dried afterwards. Now when you would occupie the same, trie how long one yard will burne, which suppose to be $\frac{1}{4}$ part of an houre, then 4 yards will be a inst houre in burning. Now suppose you haue laid some powder or balls of wilde fire to burne some house, shippe, mine, corne-stacks, &c. or that you haue placed the said pow-

der or balls in some secret place to burne some thing you are desirous to spoile, and that you would be going from the place 3 houres before it effect, then binding the one end fast to the balls, laying loose powder vnder & about the same, or wrapping the one end like a wreath amongst the powder loosely, draw out the other end, or lay it crookedly, or wrap it softly about something, so as one part doe not touch another, and fire it at the other end: which match so drawn or rolled, being iust 12 yards in length, shall kindle the thing you would burne at the end of 3 houres, according to your desire: for the rule of proportion sheweth, that if one yard require a quarter or ¼ of an houre, that 12 yards of match will burne out in 3 houres. The like order you may obserue, to answer to any time appointed.

How by Arithmeticall skill you may know what number of men, horses, or oxen, is sufficient to draw any peece of Artillerie, and how much euery one draweth a peece, so as they all draw together.

Question.

If 90 men be able sufficiently to draw a Cannon of 9000 pound weight, accounting carriage and all, I demand how many men, is able to draw a Culuering of 2500 pound weight, and how much euery man drew for his part?

Resolution.

I answer: If a Cannon of 9000 pound weight, require 90 men, the quotient sheweth mee that a Culuering of 2500 weight requireth 25 men to draw the same: and diuiding the weight of the peece to bee drawne by the number of men appointed to draw the same, the quotient will shew you how much euery man drew to his part (to wit) 100 weight.

To know how many horses is to be prouided to draw any peece Of Ordinance, and how much euery one draweth.

Question.

If three horses draw a Fawcon of 900 weight, how many horses will draw a Culuering of 3000 weight?

Resolution.

I say as before, If a peece of 900 weight require 3 horses, what will a peece of 3000 weight? and in working according to the rule, the quotient is 10, shewing that 10 horses must bee prouided to draw a Culuering of 3000 weight. Also diuiding 3000, the weight of the said peece, by 10 (being the number of horses) there will stand in the quotient 300, shewing the draught of each horse.

To know how many Oxen is to be prouided to draw any peece of Artillerie.

It is to be noted that 3 yoake of Oxen is thought to draw as much as three horses, and that 3 yoake of Oxen is sufficient to draw a Saker of 1400 weight,

Question.

How many Oxen must be prouided for a Cannon of 8000 weight?

Resolution.

In working as before, I find that 34 oxen, or 17 yoake of Oxen, will serue to draw a Cannon of 8000 pound weight. And note that whereas there doth remaine $\frac{2}{3}$ parts of a whole number, neither men, horses, nor other cattell, can in any such militarie questions bee brought into a fraction, but yet the rule it sheweth that 17 yoake of oxen is sufficient for the draught of a Cannon of 8000 pound weight, when 3 yoake of oxen serue for to draw a Saker of 1400 pound weight.

If you diuide the weight of the whole Cannon being 8000 pound weight by 34, the oxen appointed to draw the same, the quotient is 235 pound $\frac{4}{17}$: so much did euery oxe draw.

How you may wanting both oxen & horses to draw any peece of Ordinance, know presently how many men is able sufficiently to draw the same, either on plaine or marrish ground.

Question.

I shewed in a conclusion before, that 3 yoake of oxen would draw a peece of 1400 pound weight, and that 90 men would draw a Cannon of 9000 pound weight; now if there want both horses and oxen, or that you are occasioned to draw the said peece through some marrish ground, whereas horses and oxen cannot passe, I demand how many men is sufficient to hale a Saker of 1400 pound weight through the said marrish ground?

Resolution.

If a Cannon of 9000 weight require 90 men to draw the same, I finde that a Saker, weighing 1400 pound weight must haue 14 men to draw the same, and euery one shall draw 100 weight for his part.

In drawing Artillery through any soft marrish ground it is requisite to haue in readinesse, in the Master of the Ordinance his carts, which carrieth the prouisions for the Ordinance, certaine hurdels of boords, or rather flat bottomed boates, in which any peece of Ordinance may be placed carriage and all, and by force or strength of men may bee drawne as easily, as to draw the said peece on the firme land, for that the said boate is apt to

slide or swimme on the soft owish, the ropes being made fast to the forecheame or sides of the said boates, which boates doe serue also for carriage of the Ordinance, and all things thereto belonging, ouer any riuer or soft owish ground, &c.

How you may by the rule afore, know how many oxen will draw any peece of Ordinance, if you want men and horses.

I shewed that 90 men are able to draw a Cannon of 9000 pound weight, and that three yoake of oxen will serue to draw a Cannon of 1400 pound weight: now wanting men and horses, I say, If a Saker of 1400 pound weight require 6 oxen, what will a Cannon of 9000? and in multiplying the weight of the Cannon by 6, the number of oxen appointed to draw the Saker, and diuiding that product by the weight of the lesser peece, the quotient is 38 oxen or 19 yoake, so many must bee prouided to draw a Cannon of 9000 pound weight, which weight diuided by the 38 oxen appointed to draw the same, the quotient sheweth that euery oxe drew 236 pound weight.

How you may wanting oxen and men to draw any peece of Ordinance, know how many horses is requisite to draw the same.

Also I noted before, that 3 horses would serue to draw a Fawcon of 900 pound weight: I demand how many horses will serue to draw a Cannon of 9000 pound weight?

weight? In working as before, the quotient is 30, so many horses is requisite for that purpose: which peece, her weight diuided by the number of horses appointed to draw the same, the quotient sheweth that euery horse drew 300 pound weight. In this order you may know what number of men, horses or oxen, is able to draw any peece of Ordinance, and what euery one seuerally doth draw.

How to know how many 100. of Haberdepoize weight any peece of Ordinance, or other grosse weight containeth.

In the conclusions afore set downe, thou must note, gentle reader, that euery 100 weight of most things, is accounted after five score to the hundreth: but if thou be desirous to know how many hundreth of Haberdepoize weight any peece of Ordinance or other grosse weight containeth, thou maist by Arithmatick soon be resolued: for euery 100 of Haberdepoize weight containeth 112 pound, the halfe hundreth 56 pound, the quarter 28 pound, and the pound 16 ounces: so that diuiding the weight of any great peece by 112, thou maist easily know how many hundreth of Haberdepoize weight the same containeth.

I would know how many hundreth of Haberdepoize weight is in a Cannon of 9000 pound weight, I diuide the same by 112 as afore said, and the quotient being 80 it sheweth that a Cannon of 9000 pound weight containes 80 hundreth of Haberdepoize weight, one quarter and 12 pound.

A Tun containeth 2000 of Haberdepoize weight.

How you may proportionally proue all sorts of peeces of Artillerie for seruice whether they will hold or no.

All peeces that shoote a bullet vnder 10 pound weight, and duely fortified with mettall, being shot 3 times, first with the whole weight of the Iron bullet. Secondly with $\frac{2}{3}$ parts thereof, and lastly with $\frac{1}{2}$ parts of the same, will hold for any seruice, being charged with her ordinary charge, albeit the said peece were discharged 100 times in one day.

How you may finde out the proportionall charge aforenamed, as thus:

Suppose a peece shoote a bullet of 6 pound weight, and that you desire to know what $\frac{4}{5}$ parts in powder of the weight of the bullet is: multiply the weight of the said bullet by the numerator 4, and diuide by the denominator 5, the quotient is your desire.

Example.

6 multiplied by 4, is 30: the same diuided by 5, the quotient is 7 $\frac{1}{2}$. The like order you must vse in giuing her $\frac{2}{3}$ parts in powder to the weight of the shot, and your quotient is 5 pound.

How to proue any peece that shooteth a bullet vnder 50 pound weight, and aboue 10 pound weight.

Any peece that shooteth a bullet aboue 10 pound in weight, and vnder 50 pound, would for the first shot be charged with $\frac{1}{3}$ parts in powder of the pellets weight: for the second shot with $\frac{2}{3}$ parts, and lastly with the whole weight of the bullet.

Example.

A mixt peece shoote a bullet of 40 pound weight, the ¼ partes thereof is 26 pound ¾, and ½ partes thereof is 33 pound ½ parte.

And note, that in prooving any peece of Ordinance, whether she be seruiceable or not, her mouth would bee mounted to 20 or 30 degrees of the quadrant, or thereabout.

To know how much one coyler rope, for the draught of any peece of Ordinance is bigger than another, and how thick the one of them is.

Take the compasse of the lesser, and likewise the circumference of the greater, abating the lesser out of the greater, the remaine is your desire, which known, by the rule of proportion you may find out the height or thicknesse of the lesser.

Example.

Suppose you haue a coyler rope of 6 inches compasse, and another of 4 inches compasse, abating 4 inches from 6 inches, the compasse of the greater, rests 2 inches, the diameter or height of the greater: which knowne, frame the rule of proportion, saying: If 6 yeeld 2, what 4? the quotient is one inch ⅓ parts, shewing the true thicknesse or height of the lesser.

To know how much one coyler rope is more than another.

Take the compasse of your rope, and multiply it in it selfe, and looke how much you would haue the other greater, augment your product by the same proportion, extract the square roote, you haue your desire.

Example.

A coyler rope of 6 inches compasse squared, makes

36 inches. Now if you would haue one 3 times as much, then multiply 36 by 3, the product is 108, the square roote thereof is 10 inches and something better, and so thicke ought a rope to be that is 3 times the compasse of the other.

How by knowing the weight of a faddome of one rope, to know the weight of a faddome of any other.

A cable or coyler rope of 10 inches compasse weighing 16 pound euery faddom, how much will a faddom of that rope weigh, that is 15 inches compasse, and made of the same stuffe? I multiply the greater in it self, ariseth 225, and that multiplied by 16 pound the weight of a faddom of the lesser rope, ariseth 3600, the which diuided by 100, being the square of the lesser rope, the quotient is 36 pound, and so much will euery faddome of the greater rope weigh. In this order by knowing what a faddome of the greater rope weigheth, you may soone finde what a faddom of the lesser rope weigheth.

How by knowing the quantity or compasse of any small rope, to find out the same in another that is many times that bignesse.

Admit I haue a small rope of 3 inches compasse, and that it is required to know the height of another that is 5 times that compasse. I square the number 3. ariseth 9, which multiplied by 5, makes 45, the square roote thereof is 6 inches $\frac{1}{4}$: so high is the greater. The like is to bee done of all such like demands.

To

To know the weight of a whole coyler rope for the draught of any peece of Ordinance.

Question.

There is a coyler rope of 8 inches compasse, weighing 12 pound euery faddome, I demaund the whole weight of that rope being 20 faddome long?

Resolution.

Multiply the number of faddoms in the rope (being 20) by the weight of one faddome, the product is 240 pound weight, your desire.

The length of a coyler rope for a whole Cannon ought to be 70 faddome or thereabouts.

For an ordinary Cannon 64 or 66 faddome, and for a demy Cannon 60 faddome or thereabouts.

For a Culuering 40 faddome, a demy Culuering 36 faddome, and a Saker 30 faddome, &c.

To find out the superficiall content of the hollow concauity of any peece.

If you multiply the length of the cilinder or bore of the peece, by the circumference of the hollow concaue about the mouth, the product will shew you the superficiall content of the cilinder of the said peece.

Example.

A Cannon of 7 inches diameter hauing her concaue or hollow cilinder 12 foote in length, how much is the superficiall content thereof?

Resolution.

Reduce the length of the hollow concaue of the peece into inches, ariseth 144 inches, which multiplied by 22 inches, the circumference of the concaue at the mouth of the peece, ariseth 3168 inches, the

superficiall content of the mettall compassing the concaue of the peece.

To find out the crassitude or solid content of the cilinder or concaue of any peece.

First, you must by the rules taught in the beginning of the booke, find out the content of the base or plaine of the concauity at the mouth of the peece, in multiplying $\frac{1}{2}$, the diameter in halfe the circumference; or else squaring the diameter, and multiplying that product by 11, and diuiding the result by 14, the quotient will also shew you the content, the which multiplied in the length of the cilinder of the peece, the product is your desire.

Example.

The Cannon aboue named of 7 inches diameter, wrought as is shewed, yeeldeth 38 inches $\frac{1}{2}$ at the base or circular content of her mouth, which multiplied by 144 inches, the length of the cilinder, yeeldeth 8280 inches, the solid content of the concaue of the said peece.

If you desire to know how many foote in square measure, the solide content of the empty or hollow concauity of the peece aforenamed, or any other doth containe, you must worke thus; deuide the number of inches in the solide content thereof by the number of inches in a foote square, being 1728, the quotient is your desire.

Example.

The solide content of the peece of 7 inches diameter aboue named, containeth 8280 inches; which deuided by 1728, the quotient is $4\frac{77}{72}$, that is, 5 feete in square measure wanting 15 inches. The like is to bee done in any other peece, or in measuring the cilinder or Cone in any other solide body.

ficiall content of the mettall compaſſing the con-
of the peece.

find out the craſsitude or ſolid content of the cilinder or concaue of any peece.

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diameter in halfe the circumference, or elſe ſqua-
he diameter, and multiplying that product by 11,
iuiding the reſult by 14, the quotient will alſo ſhew
he content, the which multiplied in the length of
ilinder of the peece, the product is your deſire.

Example.

he Cannon aboue named of 7 inches diameter,
ght as is ſhewed, yeeldeth 38 inches ½ at the baſe
cular content of her mouth, which multiplied by
nches, the length of the cilinder, yeeldeth 8280 in-
the ſolid content of the concaue of the ſaid peece.

our deſire to know how many foote in ſquare mea-
he ſolide content of the empty or hollow concaui-
the peece aforenamed, or any other doth containe,
muſt worke thus; deuide the number of inches in
olide content thereof by the number of inches in a
ſquare, being 1728, the quotient is your deſire.

Example.

he ſolide content of the peece of 7 inches diameter
e named, containeth 8280 inches, which deuided
728, the quotient is $4\frac{12}{13}$, that is, 5 foote in ſquare
ure wanting 15 inches. The like is to bee done in
ther peece, or in meaſuring the cilinder or Conelin
ther ſolide body.

How you may Arithmetically know how much any peece of

A Table wherein you may finde the names of the great Ordinance now vsed for offensiue or defensiue seruices; the height of their diameters, their weight, and length, the thicknesse of their mettall at the breech, trunnions or necke: the number of Men, horses, or oxen, requisite for the draught of each peece in time of need; the height, weight, and compasse of the bullet belonging to euery peece of Artillery: And how much corne powder is requisite to charge euery great peece of Artillery. And also the length and breadth of the ladle fit for euery peece; As the length, breadth, depth, or thicknesse of the carriage of each peece, the distance each peece shootes at point blanke and vtmost range. And how long euery coyler rope ought to be for the draught of each peece, after the account in feet and inches of Assize of England, and Habberdepoiz weight of the same.

The names of the peeces of great Ordinance.	The height of the diameter of euery peece, in inches and parts.	Height of the bullet in inches and parts.	Weight of the shot in pounds and parts.	Compasse of the shot in inches and parts.	Weight of corne powder due to charge each peece in pounds and parts.	Weight of the peece in pounds about.	Length of the peece in feet about.	Thicknesse of the mettall at the touch-hole, in inches and parts.	Thicknesse of the mettall at the trunions.	Thicknesse of the mettall at the necke of each peece.	Length of the ladle in inches and parts.	Breadth of the ladle.	Length of the planks of the carriage in feet.	Breadth or depth of each plank at the fore-end in inches.	Breadth of the planks at the lower end.	Thicknesse of the planks in inches and parts of inches.	The number of men sufficient to draw each peece in seruice.	The number of horses requisite to draw each peece of Ordinance.	The number of yoake of oxen fit to draw each great peece.	Distance of paces the peece carrieth at point blanke about.	Distance of paces each great peece shoots at vtmost random about.	The length of the coyler rope requisite to draw each peece.
Cannon.	8	7 1/4	64	25 1/2	32	8000	12	8	6 3/4	4.	23. 1/2.	15.	16. 3/4.	32.	20.	8.	90	16.	17.	300.	1500.	70.
Cannon Serpentine.	7 1/2	7 1/4	52	23 4/7	26	7000	11 1/2	7 1/2	5 3/7	3 1/4	22.	14. 1/2.	16. 1/4.	20.	18. 1/4	7. 1/2.	80.	14.	15.	340.	1600.	66.
French Cannon.	7 1/4	7	46 3/4	22 11/14	23 1/4	6500	12	7 1/4	5 2/7	3 3/8	21.	13. 1/2.	16. 3/4.	29.	18.	7. 1/4.	70.	12.	14.	360.	1740.	64.
Demy Cannon eldest.	6 3/4	6 1/2	36 1/8	21 9/14	20	6000	11 1/4	6 3/4	5 1/4	3 3/8	22.	12.	15. 1/2.	27.	16. 3/4.	6. 3/4.	65.	11.	12.	370.	1800.	60.
Demy Cannon ordinary.	6 1/2	6 1/4	32	20 5/7	18	5600	10 1/2	6 1/2	5	3 1/8	20.	11. 1/2.	15. 1/4.	26.	16. 1/4	6. 1/2	60.	10.	11.	350.	1700.	54.
Demy Cannon.	6	5 3/4	24 1/2	18 6/7	16	5000	11	6	4 1/4	3 1/10	21.	11.	16.	24.	15.	6.	56.	9.	10.	340.	1600.	46.
Culuering.	5 1/2	5 1/4	19	17 2/7	15	4600	13 1/4	5 1/2	4 1/2	3	22.	9. 1/2.	18. 1/4.	22.	13. 3/4	5. 1/2.	50.	8.	9.	420.	2100.	40.
Ordinary Culuering.	5 1/4	5	16 1/4	16 1/2	12 1/2	4300	12	5 1/4	4 1/4	2 3/4	21.	9.	17. 3/4.	21.	13. 1/8	5. 1/4	46.	8.	9.	400.	2000.	36.
Demy Culuering.	4 1/2	4 1/4	11 3/4	14 1/2	9	3000	11	4 1/2	4	2 5/8	20.	8. 1/2.	16. 1/2.	18.	11. 1/4	4. 1/2.	36.	7.	8.	380.	1800.	34.
Demy Culuering something leſſe.	4 1/4	4	9	13 5/14	7 1/2	2300	10	4 1/4	3. 3/4	2 1/2	19. 1/2.	7. 3/4.	14. 3/8.	17.	10. 3/4	4. 1/4	28.	6.	7.	320.	1600.	30.
Saker ordinary.	3 3/4	3 1/2	6	11 11/14	5	1900	9 1/2	3 3/4	3. 1/4	2. 1/2.	16.	6. 3/4.	14.	15.	9. 3/8	3. 3/4	24.	5.	6.	300.	1500.	28.
Saker et or Minion.	3 1/4	3.	4 3/4	10 3/14	3 1/2	1100	8	3 1/2	2 3/4	2. 1/4.	14.	5.	11. 1/2	13.	8. 1/8	3. 1/4	20.	4.	4.	280.	1400.	24.
Fawcon.	2 3/4	2 1/2	2 1/2	8 9/14	2 1/4	750	7	2 3/4	2 1/2	2.	12.	4. 1/2.	10. 1/4.	11.	7.	2. 3/4	16.	3.	3.	260.	1200.	20.
Fawconet.	2 1/4	2.	1 1/8	7 1/14	1 1/2	400	6	2 1/4	2	1. 3/4.	10.	3. 3/4.	8. 1/2.	9.	6. 1/2	2. 1/4	10.	2.	2.	220.	1000.	20.

Place this Table at the 87 page.

How you may Arithmetically know how much any peece of Ordinance is taper-bored, or whether the same be taper-bored, or not.

Put vpon your rammer staffe a tampion of wood, that is just the height of the hollow concaue of your peece, and thrust the same home into the peece; if it goe not home to the breech, then the peece is taper-bored; if it goe home, the peece is not taper-bored: if she bee taper-bored, then put on such a tampion of wood vpon your rammer-staffe, as may fill the concaue of the peece in the narrowest part where she is taper-bored, and be sure that it goe home to the breech of the peece, and afterwards with your compasses, measure the diameter of either tampion, abating the lesser measure out of the greater; the remaine is your desire.

And note, that the tampion at the end of euery rammer-staffe, is to thrust home the wad and bullet close to the chamber or place where the powder lyeth, and euery rammer-staffe ought to haue a sponge at the one end, to cleanse the peece with, and a tampion of wood at the other end, to put home the bullet and wad with, in the center of which ought to be a hollow screw, wherein the Gunner may screw in a wad hooke to vnloade any peece at his pleasure.

How to shoote in any morter peece.

Morter peeces were inuented onely to annoy the enemy, when other Ordinance cannot be vsed against them, as being charged with stone shot to beate down the houses of the enemy, or to fal amongst men being assembled together, or charged with bullets of wild-fire to burne the

enemies ſhips, houſes, or corne. To make a perfect ſhot in one of theſe peeces, it is requiſite you know 2 things belonging to the ſame (that is to ſay) how far your morter-peece will carry a bullet, or a ball of fire-worke, as ſhe is to ſhoote at the beſt of the randon: and likewiſe how far it is from your peece to the mark you intend to ſhoot at, which knowne you may make a perfect ſhot as thus.

Example.

If a morter-peece ſhoote a bullet or fire-worke 700 paces, and that the marke which you intend to ſhoote at is but 500 paces, I demand at what degree of the quadrant, ſhall the peece be layd at, to make a good ſhot?

Reſolution.

To anſwer this and all ſuch like, reaſon and experience teacheth, that the leſſer ground you intend to ſhoot, you muſt raiſe the mouth of your morter peece ſo many degrees aboue the beſt of the randon, as is ſufficient to reach the marke deſired: and therfore I ſay, If 700 paces require 45 degrees of the quadrant, what will 500? and the quotient tels me, that at 63 degrees of the quadrant the mouth of the ſaid peece muſt be eleuated at, to cauſe the bullet or fire-ball to light accordingly.

If you abate 45 degrees (being the beſt of the randon) from 63 degrees, that the peece was eleuated at, the remaine is 18 degrees, and ſo many degrees of the quadrant was the mouth of the morter peece eleuated at to reach the marke.

To know how farre or ſhort any morter-peece will ſhoote further or ſhorter, at the mount or diſmount of one or many degrees.

Queſtion.

A morter-peece that ſhoots 450 paces at the beſt of the

the randon, I would know how much shorter shall shee shoote, being eleuated one degree aboue the vtmost range?

Resolution.

Diuide the distance of the vtmost range being 450 paces, by 45 the degrees in the best of the randon, the quotient is 10, so many paces will the said peece shoote shorter, her mouth eleuated one degree.

How you may know very neere how farre from your peece the bullet shall light, the said morter-peece mouth being raised to what degree you thinke good.

Question.

Suppose there is a Castle, &c. beseiged, and that the Gunners had brought their Ordinance as neere as they would wish, so that hauing discharged the morter-peece in the former conclusion, at the mount of 60 degrees, they find that the bullet fals in, or about the midst of the said Castle or Fort: The question is, how farre it is betweene the peece and the fall of the said bullet?

Resolution.

You must first seeke what difference of degrees is betweene 60 and 45, and you shall find 15, then by the rule of proportion say, If one degree abate 10 paces, what will 45? and you shall find 150 paces in your quotient. And in this order by the helpe of Arithmeticke, you may find how farre it is from the peece to the marke.

Also it is possible to shoote so directly vpright in a quiet,

quiet, faire, and calme day, that the bullet ſhot out of your morter peece, ſhal fall into the peece mouth againe, or hard beſides the ſame, if you raiſe the peece-mouth iuſt to 90 degrees of the quadrant, which albeit it bee not ſeruiceable, yet it is poſsible to be done: For this is a generall rule, that no peece of Ordinance whatſoeuer can ſhoote a bullet to continue ſtill in a ſtreight line, during the motion of the ſaid bullet, except you eleuate or raiſe the concaue of the ſaid peece directly towards the zeneth of the skie, or elſe plumbe downe towards the center of the earth.

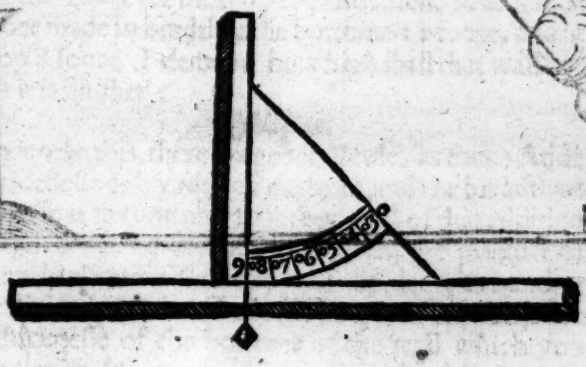
The diameter of the chamber-mouth in euery morter-peece, ought to bee equall to the ſemi-diameter in the mouth of the ſaid morter.

The length of euerie chamber in a morter-peece, ought to be once and a halfe the diameter of the chamber.

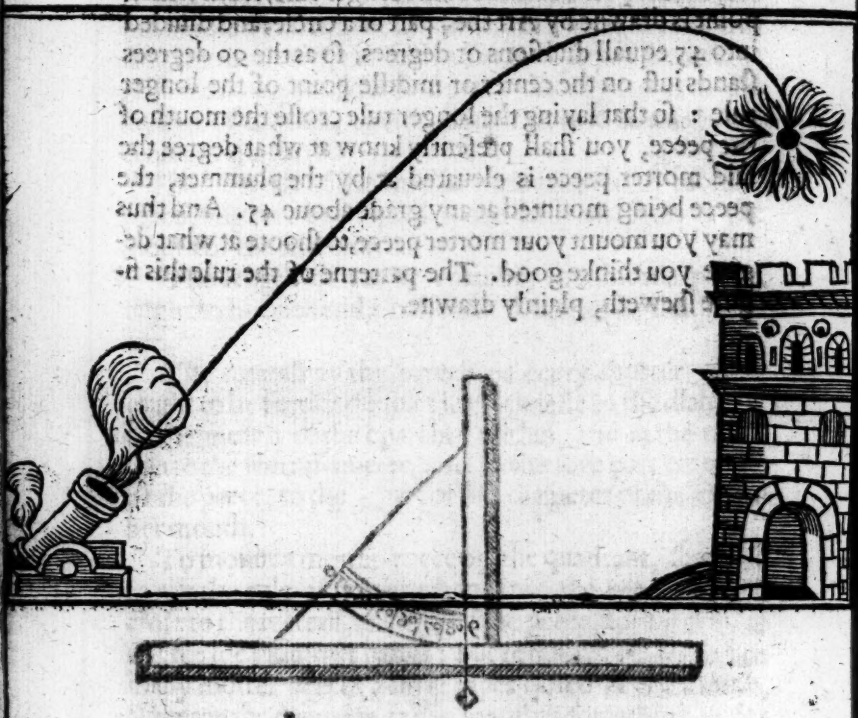
The mettall at the breech of euery morter-peece, ought to be fortified equall in thickneſſe to the diameter of the mouth of the chamber within, and at the trunions to the ſemi-diameter, and at the fore-part or necke of the peece, to the $\frac{1}{3}$ part of the diameter of the chamber mouth.

To mount a morter-peece by the quadrant, ſome vſe to put the rule of the quadrant into the peece-mouth, cloſe to the mettall, or inſide of the peece, noting at what degree the plummet hangs: but for aſmuch as there bee many morter peeces a little taper-bored at the mouth, (I meane the diameter at the mouth is ſomething wider than it is within) therefore it is the beſt to haue a rule made for the purpoſe, which among the experienced Gunners is common, the ſaid rule being about 18 inches

thes length, in the middle point or pricke whereof is another ſhorter rule, framed artificially aboue a foote long, ioyned cloſe, and falling perpendicularly on the longer rule, whoſe containing angle lighteth iuſtly on the middle point or mids of the longer rule, from which point is drawne by Art the ¼ part of a circle, and diuided into 45 equall diuiſions or degrees, ſo as the 90 degrees ſtands iuſt on the center or middle point of the longer rule: ſo that laying the longer rule croſſe the mouth of the peece, you ſhall preſently know at what degree the ſaid morter peece is eleuated at by the plummet, the peece being mounted at any grade aboue 45. And thus may you mount your morter peece, to ſhoote at what degree you thinke good. The patterne of the rule this figure ſheweth, plainly drawne.



The orderly flight or motion of the bullet or fire-ball shot out of any mortar-peece, by the figure or draught hereunder may be perceiued.



Hauing planted Ordinance vpon any mount or platforme, to beſiege any Towne &c. and that you deſire to make ſome little trench or ditch about the ſame for the defence thereof, how you may know how much the earth and turfe that is caſt out of the ſaid ditch, ſhall raiſe a wall in height, being laid orderly at the brim of the ſaid ditch, on the inſide thereof, making the ſame wall to any proportion aſſigned.

Queſtion.

Suppoſe the Generall command the Captaine of the Pyoners, that a ditch be made about the mounts or platformes where the Ordinance plaies, making the ſame 18 foote in bredth at the brim, 12 foote in bredth at the bottome, and 8 foote in depth, and that the earth and turfe digged out of the ſaid trench be laid orderly in the inſide thereof at the brim of the ſaid ditch, ſo as a wall may bee made in bredth at the bottome 12 foote, and at the top 8 foote, I demand how high ſhall that wall bee when it is finiſhed?

Reſolution.

To worke this, there is a generall rule, (as thus.) Adde the wideneſſe or breadth of the brim, and the breadth or wideneſſe at the bottome together, the ½ of that addition multiplied by the depth of the ditch, the product of that multiplication ſhall bee your diuident, or number to be diuided. Now to finde the height of the wall, adde the thickneſſe of the bottome of the wall which you meane to make, to the thickneſſe or bredth that you intend to make it at the head, the ½ of that addition ſhall bee your diuiſor, which diuident diuided by the

diuisor, the quotient will shew you the height of the wall.

Example.

The trench in this conclusion is said to be 18 foote broad at the mouth or brim thereof, and 12 foote at the bottome, which 2 numbers being added, makes 30, the halfe whereof is 15 feete, which 15 feete multiplied by 8 feete being the depth, ariseth 120 feete for my diuident. Likewise, adde twelue foote (the thicknesse of the wall at the bottome) to 8 foote the bredth you meane to make it at the head, so ariseth 20 feete, the ½ thereof is 10 feete for my diuisor, (and so thicke the said wall will be in the midst) the which diuident being 120, being diuided by the diuisor 10, the quotient is 12, and so many foote in height shall the earth and turfe casten out of the trench aforesaid, make a wall being 12 foote broade at the bottome, 8 foote at the head, and 10 foote in breadth at the midst: the said trench being 18 foote broad at the brim, 12 foote broad at the bottome, and 8 foote deepe.

In this order you may finde out the height, bredth, or depth of any such like wall or ditch, in making the same after any proportion assigned.

Briefe obseruations of certaine principals in the Art of Gunnery, for euery Gunner to consider of, to practise and learne, viz.

To know what disparture euery peece of Ordinance ought to haue in shooting either at or within point blanke, or with an inch rule at any aduantage.

To

To vse a mediocrity in ramming and wadding, and in giuing euery peece her due loading in powder & bullet.

To know the goodnesse and badnesse of powder, and how to make and make perfit good powder, and how to fine the peter, &c.

To consider the winde, whether it blow with you or against you, or on any side of the peece, and how to weather your peece to make a good shot.

To consider the platforme, whether it bee flat, or else declining for the recoile of your peece, and whether the marke be higher or lower than your platforme, as also to know the distance thereto.

To know whether your peece be truely bored or not, and how to make a perfect shot in a peece that is not truly bored.

To consider whether the one wheele be more glad or reuerse faster vpon the axle-tree than the other, or whether the one wheele stand higher than the other, lest you doe shoote wide.

To know whether a short peece will out-shoote a long peece or not, keeping the length of the marke by the like degrees on the quadrant.

To know that leuelling with the quadrant towards a hill (the marke standing higher than your platforme) you shall shoote short: and shooting into a valley, you doe ouershoote the marke, but shooting on a leuell ground you keep the length with the quadrant, and how you ought to lay your peece to make a perfect shot with the quadrant at euery marke.

To know that giuing leuell with an inch rule (which some call the rule of flat) is erroneous in shooting in peeces of contrary length, as also at leuell marks: obseruing

ſeruing one methods.

To learne to know the diſtance to the marke, and what diſtance your peece will ſhoote at point blanke, or mounted from degree to degree (which is the beſt rule to ſhoote by.)

To know whether the cariage or ſtocke of your peece haue her due length or not, and whether the peece bee truly placed therein or not.

To conſider that in ſhooting diuers peeces from one platforme, to diſcharge that peece which ſtands to the ley wards firſt, and to ſet your match or fire euer on the ley ſide, and your powder on the wind hand.

To know the true order in mixing and making all kind of fire-workes, wet and dry.

To know the height and weight of all peeces of Ordinance, and whether the ſame lye ſtreight in the cariage or not.

To know the height and weight of all bullets of like mettall, and the circumference thereof: and what proportion a bullet of one mettall beareth to the like or vnlike bullet of a contrary mettall.

To know how much Serpentine or corne powder is requiſite to charge any peece of Artillery.

To know what neceſſaries belongeth to any peece of Ordinance, being in ſeruice by land or ſea, as ladles, ſponges, hand-ſpikes, ropes, coines, &c. and what labourers ſhould attend the ſame.

To know likewiſe what men, horſes or oxen, bee able to draw any peece of Ordinance in ſeruice, or on the ſudden.

To be circumſpect of lighted matche and candles, &c. for feare of powder, being in ſea-ſeruice: and to

keepe a perfect regiſter of euery thing pertaining to your Ordinance, both what you haue preſent, and what you haue ſpent, to keepe your Ordinance drie within, and to haue in readineſſe all kinde of ſeruiceable fire-workes, which fire-workes ought to bee made either in the boate or on land, but not in the ſhip for feare of had I wiſt.

To know the vſe of all Geometricall inſtruments belonging to the profeſſion of a Gunner, as alſo to haue ſome ſight in Arithmeticke and Geometry, thereby to ſhoote at all randons, and how to mannage and handle all engines, for the mounting or diſmounting of any peece of ordinance, in or out her cariage, &c.

To know that euery peece ought to bee as thicke of mettall in euery part from the loweſt part of the concaue at the breech, to that part of the chamber that holds the powder, as the bullet due to that peece is in height.

A breuiary of certaine ſecrets in the Art of Gunnery.

A bullet violently driuen out of any peece of Ordinance by the force of the powder, flieth ſwifteſt and ſtraighteſt from the mouth, till it be paſt the diſtance of the leuell range.

The great noiſe or rore that the peece makes in deliuering the bullet (or diſcharged without bullet) ariſeth betweene the ayre within the peece, violently driuen out into the open aire by the force of the fire (the Petre or Matter being reſolued into a windie exhalation.) And according to the quantitie of the fire and aire, burſting out of the peece, ſo is the cracke more or leſſe.

Any bullet ſhot out of a peece lying leuell, doth flie

flie more heauily, and worketh leſſe effect in piercing an obiect, than when the peece is eleuated at any degree or degrees of the randon.

A heauie bullet violently mouing pierceth forer than a lighter bullet, hauing the like motion.

A bullet of lead ſhall worke as great effect againſt an obiect, as the like bullet of iron, hauing the like motion, by reaſon of his ouerplus of weight.

A bullet ſhot out of any peece of Artillery, will pierce more againſt any thing ſtanding firme, than againſt a moueable obiect, and ſhot at an obiect a reaſonable diſtance from the peece, will pierce more effectually, than ſhot at the ſame neerer hand.

Euery bullet doth make a long or ſhort range, according to the eleuation of the peece out of which it is ſhot.

A bullet flieth euer furtheſt in his ſtreight motion (or in an inſenſible ſtreight line) the heigher that the peece is eleuated at the mouth.

Any peece diſcharged twice with one and the ſelf like quantity of powder, wad, and bullet, hauing one and the ſelfe like proportion in ramming and wadding, and ſhot at one like degree of randon, the peece of like temper at either ſhot ſhall make like ranges, but the ſaid peece diſcharged as afore, but not of like temper, ſhall make ſeuerall grazes.

Two peeces in all reſpects equall, ſaue onely that the one is ſomething longer than the other, diſcharged with one like quantity in powder and bullet, ſhall make ſeuerall grazes, according to the length of the cilinder of the peece, the longer ſhall out-ſhoote the ſhorter.

Two peeces in all reſpects equall, ſaue onely in length, diſcharged at a marke of equall diſtance from

each

each peece, and being within the range of both peeces, the bullet ſhot out of the ſhorter peece, ſhall graze or beate the marke, before the bullet ſhot out of the longer peece.

Two peeces proportionall in all reſpects, being diſcharged with one like quantity and kinde of powder, but differing in bullet, as the one Iron, the other lead, and both bullets of like height, ſhall make ſeuerall ranges, the Iron bullet ſhall outflie the leaden bullet, but diſcharged with a bullet of mettall, and afterwards with a like bullet made of wood, obſeruing one and the like quantitie in powder at euery ſhot, the bullet of wood ſhall not flie ſo farre as the like bullet of mettall.

A peece any whit eleuated at the mouth, will ſhoote further in an inſenſible ſtreight line, than lying leuell: and by how much more any bullet is driuen more ſwifter through the ayre, by ſo much it is made the more lighter in the mouing or drift thereof.

Two peeces alike in euery reſpect, ſhot with one like bullet, but different quantitie of powder, ſhall make ſeuerall ranges. Alſo the ſaid peeces and bullets equall in all reſpects, and the powder alſo in quantitie equall, ſauing that the mixtures of the ſaid powder is not alike, ſhall make ſeuerall ranges.

One peece diſcharged diuers times with one like bullet, firſt with the quarter of the weight of the bullet in powder, after with halfe the weight, thirdly with ¾ parts of the weight, and laſtly with the whole weight of the bullet in corne powder, and the ranges differing at point blanke noted, the ranges at the vtmoſt randon differing, ſhall be proportionall, one method in charging, &c. being obſerued.

To euery peece of Ordinance, according to the proportion of the diameter, length of the cilinder, and weight of the bullet belonging thereto, there is a due quantity of powder to be allowed, so that charging the peece with more or lesse than the said due proportion, shall rather hinder than further the bullet in his further range.

By how much the mettall of any peece is made hotter by often shooting, than it was before you made the first shot, by so much is the concaue or bore of the peece made more attractiue, the mettall dulled and the peece worketh lesse effect than in the beginning.

All peeces in whose mettall is mingled most tin, lead, or copper, is more attractiue a great deale than those peeces in whom is put most bel-mettall.

A brasse peece made hot with often shooting, is more apt to breake than when it is cold; and any peece of Artillery is more apt to breake at the first or second shot in a hard frost being cold, than made hote with often shooting.

Any peece of Ordinance discharged, hauing her full charge in powder, will range and pierce further, than wanting any part thereof; and hauing a little quantitie more than her due charge in powder, will ouershoot the other, but it will danger the peece: but doubling the weight of the bullet in powder, shall shoote lesse ground than hauing a meane proportionall charge in powder (to wit, betweene the parts and the whole weight of the bullet) for that the cilinder of the peece is too much choked, and the bullet driuen out into the open aire before the powder be all fired.

Euery peece of Artillery ought to haue her conuenient length and weight of mettall, according to the pro-

proportion of the diameter or bore of the ſame, and being made longer or ſhorter than her ſaid due length, will rather hinder than further her vtmoſt range.

Any peece of Ordinance made hote through much ſhooting, will neither range ſo farre, nor pierce ſo deepe, as being temperately cold.

No peece of Artillery can ſhoot a bullet to range ſtill in a perfect ſtreight line, except you ſhoote the ſame either directly vpright towards the zenith of the ſky, or elſe directly plumme downe towards the center of the earth.

The right line of the vtmoſt randon in all peeces, is more than the right line of the leuell range, and the right line of the vtmoſt range, is not ſo much as the right line of 90 degrees.

The vtmoſt range in all ſorts of peeces, is not at iuſt 45 degrees of randon, as *Tartallia* and diuers others do affirme, but ſhooting with the wind in a quiet or calme day, is at or about 45 degrees, but the wind againſt, or on any ſide, or rough, or the aire thicke, &c. will range as farre at or about 40 degrees.

Two peeces in all reſpects equall ſaue onely in length, diſcharged with a like quantity in powder, wad, & bullet; and ſhot at a marke within the reach of both peeces, mounted at like degrees of randon with the quadrant, the ſhorter peece ſhall outſhoote the longer.

The right lines made by any 2 peeces at one degree of randon diſcharged, are proportionall to the ranges of their bullets at the ſame degrees of randon, and the right lines made by any 2 peeces at any randon, are proportionall to their vtmoſt ranges.

Any peece of Ordinance firſt diſcharged with the whole weight of the bullet in Serpentine powder, & after

discharged with, the weight of her bullet, in such corne powder as shall cause the peece to range the same ground: and lastly discharged with halfe the quantity of either sort of powder, the second ranges shall not bee equall, although the manner of charging and temper of the peece be all alike.

Three peeces in all respects equall, saue euery one exceeds other in like proportion in length, the vtmost ranges of their bullets shall not be alike proportionall, although the forme of charging be vniforme and alike.

A peece twice charged, first with an Iron bullet fit for the same peece, and after with a leaden bullet of the like weight, but differing in height, and with one and the like quantity in powder and wad, at either time the Iron bullet shall outflie the leaden bullet.

A peece discharged first with an Iron bullet, and after with a leaden bullet of like height, and at either time discharged with the weight of the bullet in Serpentine powder, shall make vnequall ranges.

A peece twice discharged at like degree of randon, first with an Iron, and then with a leaden bullet, and after discharged with any other quantity of powder, the ranges of the bullets shall not retaine the same proportion.

If 2 peeces of one length but differing in bore, the one discharged with an Iron, the other with a leaden bullet at one like randon, hauing the weight of either bullet in course powder, doe range both alike ground, and the said peeces after discharged with halfe the weight of their bullets, of the same or any other powder, shall not range one like distance of ground.

Two peeces of one mettall and length, but of different

bullets

bullets equally mounted, discharged with any like quantity of one powder, shall not range iustly one distance of ground.

The proportion of the different ranges, that Iron and leaden bullets make, being found by experience in any one peece of Ordinance, the same proportion will not hold in all other peeces of Ordinance of contrary length, that shootes the same like bullet.

Any peece of Ordinance being thicker of mettall on the one side than on the other, discharged at a marke, will cast the bullet towards that side, that is thickest of mettall.

Two peeces of contrary length, but of like diameter, hauing both one like charge, being shot off at a marke within the reach of both peeces, giuing leuell with an inch rule, at one like height of the rule, shall make seuerall grazes, the shorter peece shall outshoote the longer.

Any peece of Ordinance will conuey the bullet more ground, her mouth eleuated at 18 or 20 degrees, than from the said grades to the best of the randon, although there be 7 degrees vantage in the latter.

Any peece of Ordinance hauing her due loading, will conuey the bullet more than fiue times the distance of her leuell range.

A Table shewing the contents of this Booke.

A Table of the deminute parts vsed in mensurations. 1.

A table shewing how to weight any great quantitie with few weights. 2.

How to extract the cubicke radix or roote of any number, and how to finde a true denominator to the cubicke remaine, and how to proue if you worke right or not. 4.5.

Theoremes, shewing the proportion betweene a bullet of one mettall, to a bullet of contrary mettall, and between the diameter and circumference thereof, &c. 8.

How by knowing the true weight of any bullet, and diameter of the peece due for the same, to find the weight of any other bullet of like mettall belonging to a contrary peece of Ordinance. 8.

How by the knowne weight of any small bullet, you may finde out the weight of a greater, and how to proue if you worke right or not. 9.

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By knowing the weight and diameter of an iron bullet, to finde the height and weight of a leaden bullet of the same proportion: or contrariwise, by knowing the weight of a leaden bullet, to finde the weight of an iron bullet of like height. 12.

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To

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How to make a ladle for a chamber bored peece. 28.
To find out the height of the diameter of the chamber in any chamber-bored Cannon, or other peece: and how to find out the thicknesse of mettall, round about the chamber thereof. 29.
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FINIS.

FINIS.

CERTAIN ADDITIONS TO THE BOOKE OF GVNNERY, with a ſupply of *Fire-Workes*.

All done by the former Author *Thomas Smith* Souldier of Barwicke vpon Tweede.

Both pleaſant and profitable.

LONDON,
Printed by *H. L.* and are to be ſold by *R. Dawlman*, in Fleet-ſtreet neere the great Conduit. 1627.

STC 21856

CERTAIN ADDITIONS TO THE BOOKE OF GVNNEZY, with a supply of Fire-Workes.

All done by the former Author Thomas Smith Souldier of Barwicke vpon Tweede.

Both pleasant and profitable.

Printed by H. L. and are to be sold by E. Dawson, in Fleet-street neere the great Conduit. 1627.

CERTAINE PRINCIPALL points belonging to the Art of GVNNERIE.

I Reade in *Tartaglia* of Powder that shall make no noyse being fired out of any peece of great Ordnance, where he saith it is nor lawfull to be vsed, neither to shew the making of it. But I am assured he neuer burnt any of it: for he doth confesse in his Epistle to his booke, that hee neuer shot in any Peece. Also I haue heard it confidently affirmed, that there is forcible powder (of a white colour as they say) the which being fired out of any peece of Ordnance, the peece hauing had her due loading therof, it shal make no rore, crack or report (as we terme it): but I neither beleeue the one nor the other. For I say it is impossible to make Powder that shall burne and haue anie force, but that the flame therof being resolued into a windy substance, enclosed within the concaue of the Peece, violently thrusting it selfe out of the Peece into the open ayre, must of necessity giue a rore or crack, more or lesse, in proportion to that ayrie substance so fired, & compacted within the Peece: many examples I could alledge for further proofe hereof.

The vertue & force of gun-powder consists in the

Salpeter, for the brimstone & the cole is but onely to maintaine the flame therof: for the brimstone is fat, is apt to flame with any sparkle, and once flamed, causeth the matter or Salpeter to flame. The cole is apt to kindle or burne with any sparkle, but not to flame, yet maintaineth the flame of the other two materials. The best Matter is that which is refined without any fatnesse. The best brimstone is that which hath no drosse in it. And the best cole are those that are made of the softest & lightest wood. These three materials being pounded very fine, & their true proportions parts mixed & wrought accordingly by such as haue skill in the art, makes perfect good powder, the vse wherof was neuer better known than in these present dayes. The goodnesse of any powder may be known by the colour, by the taste of the tongue, and by the burning, and a man may make as much and as little thereof at a time, as he pleaseth, hauing prouision of furniture for that purpose.

Any Peece discharged diuerse times with moyst powder, will sooner heate, than being discharged the like number of times with like quantitie of fine dry powder: for the moist powder is longer in burning, & causeth the peece to worke lesse effect than if it had beene charged with like quantity of dry powder.

If you haue by experience found that your powder is not forcible, the neatest way to strengthen the same is, by putting to euerie pound thereof one ounce of refined Matter finely pounded, and then moistening the same with vinegar, or rather the water of Salpeter, & beating the same in a mortar vntill it be verie finely as you can, with a wodden pestell (for it is dangerous

rous to beat the same with any iron toole for fear of a sparke) & sifting the same thorow a verie fine sieue, corning & drying the same, it will be of more force a great deale than it was at the first time. Soon do make excellent good corne powder, so fine, that the cornes thereof are like Thime seed.

I haue read & heard some of that opinion, that if a little quicke-siluer bee put in amongst the powder where with any peece is loaden, & a close wad thereafter, that that peece shall giue a greater report than if she had been charged with the same like quantity of powder and wad, and wanting the quicke-siluer, the which I did experiment in a Galliuch, but could perceiue no such matter.

If you would outshoot any other man in any one peece of Ordnance, the peece to be loaden at eyther time with one like quantity of one like powder, wad & bullet, & discharged at one like random, then after you haue loaden the peece with her due of powder, put the same closely home with the end of your cammer staffe, & after make a rolled wad as hard & close as you are able to thrust home to the powder, and put your bullet close home to the said wad, but put no wad after it, or the marke lye so as the peece mouth be any whit cleuated, otherwise put in a little wad after the bullet, to keepe the bullet close to the wad in his right place. Also if you take strong cantus soaked in oyle, & sow the same close & round about the bullet, that the bullet may fill the hollow cilinder of the peece, & put the same close home, as afore, that bullet will range further than being discharged hauing a lusse wad, & being vncoated. *Fert alia* affirms, that the

powder put into the peece and rammed home to the breech, being bored thorow with a staffe of an inch or ¼ in thicknesse, to the breech of the peece, & after a close wad put home to the said powder, & the bullet put home after it, that that bullet shall range more ground than it would haue done if the powder in the peece had not been bored thorow, as is aboue said.

Any peece being charged with very dry powder, that is hard corned, shall not fire all the powder, but a great many of these cornes will passe out of the peece vnburnt when the peece is recharged, as you may by experience proue out of a Musket or Calliuer: and the closer that the wad is made that is put into the peece after the powder, it wil cause more of the powder to fire, than hauing a lesse wad.

Any peece of Ordnance although the same be loaden with verie good and dry powder, if the peece lye long loaden, the powder will grow moist, by reason the Salpeter will work and grow dankish within the chamber of the peece where the powder lyeth: & if the said peter be not well refined, it will sooner grow dankish than that which hath been well refined: also the same will grow moist sooner in the winter than in the summer, & sooner on the sea than on the land.

Two peeces in all respects equall same length, at point blank, or at any degree of the randon, discharg'd with one like bullet and quantity of powder, the longer peece will still outshoote the shorter: but giuing the shorter peece a more quantitie of powder than the longer, the shorter peece will outshoot the longer.

A Musket that shooteth ½ parts or ¾ in powder of the bullet weight that is fit for the said Musket, will

range

range further & pierce deeper than a Calliuer that is recharged with a fit bullet and ⅓ or ¼ parts of his bullets weight: but in giuing to eyther peece a like proportion of powder, I meane giuing the Musket but ⅓ parts in powder of the weight of the Calliuers bullet, then shall the Calliuer do more execution, and range further than the Musket. And in like case a Fawcon or Saker being discharged with the whole weight of powder of the bullet fit for the said peece, shall doe more execution and range further than a Canon or Culuering that shooteth a fit bullet, and hath but the like quantitie of powder that the lesser peece hath.

Any peece of Ordnance that is presently recharged after her loading, or that hath not lien long loaden, will conuey her bullet more ground, & do more execution, than letting the same peece lye long loaden, the piece discharged at eyther time at one like degree of randon, and with one like quantity of one like powder, wad and bullet.

Two peeces in all respects equal, both loaden alike with one like powder, and laid at the marke from one like platform, the center of the marke iust point blank with the center of the hollow cilinder of the peece, and within the lenel range of both peeces, the one of the said peeces brought to the marke with her true disparture, and the other peece with her mettals, that peece so disparted shal strike the marke, and the other peece shall shoot ouer the marke.

A bullet of any mettal discharged out of any peece of Ordnance, by how much more violent or swifter it is driuen thorow the ayre, it is in proportiō to that violent mouing so much the lighter, and the more

lighter

lighter, the more easie is the passage thereof, and the more forcibly it flyeth, the more force it worketh against any resisting object, and flyeth in a straighter line in his swift motion, than in his decreasing mouing. And by how much the swiftnesse thereof decreaseth, in like proportion to that mouing doeth it grow heauier and declineth.

A bullet of iron or any other mettall that is not solidly cast, but hath in it som little hole or empty place, being discharged out of any peece of great Ordnance doth fly thorow the aire with a more whistling sound than if the same had been perfectly solid and round cast. And any bullet recharged from any peece of Ordnance, will make a greater sound passing violently thorow the ayre, at the first shot, than at the second, third, or fourth shot, being recharged one presently after another, by reason the ayre at the first shot was quiet, close, and vndiuided, and therefore of force must resist the passage of the bullet more than when the same is moued or diuided.

The violent motion of a bullet discharged out of a Cannon or Culuering, or other such like great peece of Ordnance, passeth with such a strong motion, and driueth the aire before it in the passage or range thereof, that flying ouer houses three or foure hundred yards about the same, doth often shake them in such sort, that the glasse on the windows will break in pieces, & the platters on the benches, or such like things standing loose, will fall down, & the higher that such houses are that are so vnder the passage or range of the bullet, are more subiect to be hurt or shaken then lower houses which are nearer to the peece, and

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vnder the like range of the bullet, wch is a ſtrange thing, that the motion of the ayre driuen & driuing the bullet, ſhould haue ſuch a power to ſhake or hurt a great obiect rather than a leſſer, both ſtanding vnder the like paſſage of the bullet. Alſo it hath more power to hurt an obiect ſtanding firme (tho further from the peece) than a moueable obiect, as a man or beaſt, being much neerer to the peece, & both vnder the range or paſſage of the bullet.

Any Peece being diſcharged with her due loading in powder & wad, with a fit bullet of yrõ, & after being diſcharged with the like quantitie of like powder & wad, & with a bullet of lead of like diameter to the yron bullet, ſhal make ſeueral ranges, thogh the peece be diſcharged at one like grade, the bullet of iron ſhal outfly the bullet of lead; but loding the peece with her due of pouder, according to the weight of the yron bullet, & after loding her with the ſame pouder, giuing her the like proportion to the weight of the leaden bullet, the range of the leadẽ bullet ſhal extẽd furder than the range of the iron bullet

Two peeces of like bore, but contrary length, hauing one like loading, and laid at one like degree of the quadrant, to ſhoot at any one marke, without the leuel range of each peece, but within the beſt randõ of both peeces, ſhal make like ranges: but if the ſaid peece haue one like viſual ſight (to wit) if they haue both one like length giuen them by an inch rule to reach the ſaid marke (which ſome Gunners call the rule of flat) the ranges of thoſe 2 peeces ſhall greatly differ, & though they haue both one like lẽgth giuẽ thẽ by the ſaid rule to reach the mark, yet ſhall they alter by the degrees of the quadrant, the ſhorter peece ſhal be eleuated at a higher point than the longer, & therfore of force muſt range furder than the lõger

It is a common opinion amongſt a great many Gunners, that any peece of Ordnance lyeth point blank that is truely brought to the marke, whether the ſaid Marke be aſcending or deſcending, the peece laid truely againſt the ſaid Marke without any length giuen to reach it: but I ſay, that there is but one preciſe point blanke, that is, when the peece is ſo laid that the line iſſuing from the centre of the hollow cilinder of the peece cutteth the centre of the marke; and if it were or might bee extended forth right, would cut directly the true horizon: or a point blanke or leuell line is that which by ſuppoſition extendeth it ſelfe from the centre of the peece thorough the centre of the marke vnto the true horizon, for there can be but one preciſe ſtreight line or point blank, as the Gunners tearme it, which muſt be that viſuall or ſuppoſed line, whoſe ends are both of equall height. Or a direct ſtraight line is that which when a perpendicular line falleth thereon, diuideth it into equall angles, as is taught in Ewclid and other bookes of Geometry. The eaſieſt and trueſt way to know when your peece lyeth point blanke, is by putting your rule into the peece mouth, hauing a Gunners quadrant or ſquare thereon, and coyning your peece ſo, that the plummet may cut or fall on the line that makes the right angle from the centre where it hangs (called the leuell line) that peece then lyeth point blanke: all other lines viſuall being extended to any marke that is eyther higher or lower than the eye, are not to be termed ſtreight lines.

If the marke which you are to ſhoot at be in a ſtreight line with the concaue of the peece, and not without the point blanke or leuell range of the peece, it is an eaſie matter to ſtrike diuerſe markes ſtanding in the ſaid line,

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by making the viſuall line ſo much lower, as is betweene the true viſuall line and the center of the cilinder of the peece, being the line in which the bullet flieth: & if the marke be far without point blanke, it is poſsible to ſtrike two markes ſtanding in the viſuall line, both in the place where the bullet firſt cutteth the ſaid viſuall line, and ſo rangeth aboue it into the ayre in his ſtraight motion (which will not be farre from the peece) & in that place where the bullet in the end of his range declining, cutteth the ſaid viſuall line againe in his crooked or bending motion, which muſt of neceſsitie be eythe. at or very neere to the marke.

If the marke you meane to ſhoot at be not far without the leuell range of the peece, and ſomething higher than point blanke, then muſt you ſo lay the peece, that the viſuall lyne aymed by the ſuperficies of the mettals of the peece (not diſparting the ſaid peece) may cut the mark: and if at the firſt ſhot the bullet light ſhort or ouer, you may eaſily amend the ſecond by adding or abating the length giuen; but if the marke be vnder point blank, and not far without the leuell range of the peece, then ſet vp your diſparture in the mids of the ſuperficies of the mettall at the mouth of the peece, and working as is ſaid by experimenting one ſhot, it is an eaſie matter to make a perfect ſhot the ſecond time: & if you ſhoot at the ſaid marke not diſparting your peece, then muſt you lay the peece ſhort of the mark, that the viſuall line paſſing by the metals of the peece touch a prety diſtãce vnder the mark

All marks or obiects diſtant frõ your peece which you are to ſhoot at, are in a threefold proportion to be conſidered of; as either the ſame is iuſt point blanke, which is in one reſpect only to be conſidered of, or it is higher

or lower than point blanke, which is to be considered of in diuers respects, according to the distance and number of degrees the same is at, eyther in ascent or descent.

Any two or mo peeces of like or contrary proportion at point blanke discharged, euery peece hauing her due loading with powder, & with a bullet fit for each peece, & the leuel ranges of the said peeces noted, that of those peeces whose leuell range is furtheſt, will still out-shoot the other at any grade of the randon, giuing to euerie of the said peeces, the self like loading in powder & bullet.

Any two peeces differing in proportion, & the difference of their leuell ranges known, may so be loaden, as they shall both range one like distance of ground at one like randon: and the vtmoſt range of any peece knowne at any degree of randon, by abating the proportion of her powder, it is posſible in two or three shoots, to shoot any part of the same randon that you will assigne.

Two peeces in all respects equall saue length, mounted one like degree of randon, and loaden with one like weight in contrary powder, and with one like bullet, that peece that is loaden with the beſt powder, will still out-range the other, although that other be the longer: but if there be but little difference betwixt the force of the powders, this proportion will not hold at euerie grade of the randon.

To charge any peece of Ordnance Gunner-like, set your boudge or barrell on the wind hand of the peece, & causing one of your assistants to hold the same aslope, thrust your ladle into the same, filling it full of powder, causing your fellow that holds the boudge to strike the same with a ruler; two of those ladles is the common charge of that peece. And fixing your thomb iust vnder

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the ſtaffe of the ladle, thruſt the ſame home to the chamber of the peece where the powder lyeth, turning the ladle ſo as your thomb be directly aboue the ſtaffe, and in ſo doing, the powder will fall or turn out of the ladle cleanly; then drawing out the ſaid ladle with the rampion on the other end of the ſtaffe, thruſt home the powder with 2. or 3. ſtrokes, cauſing your aſsiſtant to hold his thomb cloſe on the touch-hole of the peece; then taking a cloſe round wad of hay, tow, vntwiſted rope, or ſuch like, thruſt in the ſame with your rammer-ſtaffe cloſe to the pouder; & after put in the bullet cloſe to the wad: & if your peece be eleuated at any degree of the randon to reach the mark, it is needleſſe to put in any wad after the bullet, for it will rather hinder than helpe the ſame: but if the peece mouth be any whit embaſed, then it behoueth to put in a wad cloſe to the bullet, to holde the bullet in his right place: & the ſpeciall point belonging to a Gunner in charging of any great peece, is to loade the ſame ſtanding ſidewiſe of the peece, and not directly before her mouth; for it ſometimes happeneth, that a peece hauing flawes or hony-combs within her, being often diſcharged together, doth for a ſeaſon keepe ſome ſparkes of fire in the ſaid holes, ſo that thruſting home the ladle with the powder, to loade the peece ſtanding directly before the mouth of the peece, it taketh fire and killeth the Gunner and ſuch as are directly before the mouth of the peece, as happened in Anno 1573. at the ſiege of Edenborough Caſtle, to two experienced Gunners, who if they had ſtood ſidewiſe to the peece, might haue eſcaped that danger.

If you charge your peece with a cartredge, & hauing put the ſame home to the breech, with the end of your

rammer ſtaffe, put after the ſame a good wad, and after that the bullet, as afore is taught, not forgetting to thruſt the caſe of the cartredge thorow with your priming yron in the touch-hole of the peece, that the priming powder may be ſure to take hold and to fire the ſame. Some vſe to put a Tampion of wood in next to the cartredge, and then the bullet and wad; and ſome vſe to cut that part of the cartredge away that lyeth next to the touch-hole: but howſoeuer you cut the ſame in charging any peece with a cartredge, it behoueth you to prime the cartredge through with a skrewed or wreathed priming yron made ſharpe at the end, and then putting in your priming powder, you ſhall be ſure not to faile of your purpoſe.

In giuing fire to any great peece of Ordnance, as Cannon, Culuering, or ſuch like, it is requiſite that the Gunner thereto appointed, firſt ſee that the peece be well primed, laying a little powder about the touch-hole as a traine, and then to be nimble in giuing fire, which as ſoone as hee eſpyeth to flame, hee ought with quickneſſe to retire back three or foure yards out of the danger of the reuerſe of the wheeles and carriage of the peece: for oftentimes it happeneth that the wheele or axel-tree doth breake, and ſpoyle the Gunner that giueth fire, not hauing agilitie to moue himſelfe from the danger of the ſame: yea, I did ſee a Gunner ſlaine with the reuerſe of the wheele of a Culuering, which cruſhed his leg and thigh in peeces, who if hee had had a care, and nimbleneſſe withall, might haue eſcaped that misfortune. Alſo if the priming powder bee dankiſh, or the cole of the match not cleere, the Gunner cannot ſpeedily giue fire, and therefore behoueth to

foreſee it: or if he hold the lintſtocke in which his fired match is tyed, long ouer the touch-hole, the violence of the flame iſſuing thereout is able to ſpoyle him, or ſome thereabout, by throwing the lintſtocke or ſtaffe which he giues fire with out of his hand. I haue ſeene the lintſtock and match blowne out of the Gunners hand more than foureſcore yards from the peece, by the violent blaſt of the fire iſſuing out at the touch-hole of the peece, in giuing fire to the ſame. And it is to be noted, that the wider the touch-hole of the peece is, the greater flame doth iſſue out thereat, which cauſeth the peece to worke leſſe effect than ſhee would, hauing a leſſer touch-hole.

Any peece of Ordnance truely diſparted, ſhooting at any mark in a ſtreight line from the centre of the hollow concaue of the peece, and within point blanke, ſhall ſtrike ſo much vnder the centre of the ſaid marke (being laid iuſt againſt the midſt of the ſaid marke) as the viſual diſtance is from the top of the ſaid diſparture to the concaue or cilinder of the peece.

To make a perfect ſhot at any marke, whether the ſame be at point blanke, or at any degree aſcending or deſcending, coyne your peece ſo that the centre of your eye in ayming lye cloſe to the ſuperficies of the middle part of the mettall at the breech: and if the marke be at point blanke, and the peece truely diſparted, and the viſuall line ſo aymed (paſsing by the top of the ſaid diſparture) cut the centre of the marke, then ſhall the bullet light ſo much vnder the centre of the marke as is betweene the concaue of the peece and the top of the diſparture, if the winde alter not the bullet in his motion. And if the marke bee further than the peece will

reach

reach with her mettals, then muſt you eleuate the peece mouth ſo many degrees as will reach the ſame, firſt laying the peece ſtraight againſt the ſaid Marke: and whether the marke be point blanke, aboue point blanke, or vnder point blanke, if you fixe your eye in ayming aboue the leuell ſight at the breech, the viſual line paſsing by the extreme or top of the leuell ſight at the mouth of the peece, will cut vnder the mark, and will cut or diuide the ſuppoſed line in which the bullet flyeth before it come to the marke; which bullet will light aboue the marke: or fixing your eye lower than you ought at the breech, the viſual line extending it ſelfe, will cut aboue the marke, and neuer touch the line in which the bullet flyeth.

Any peece of Ordnance made hote with often ſhooting, being cooled with water, or vineger, or other liquor, and preſently after recharged againe, will not conuey the bullet ſo farre, as ſuffering the mettall to coole of it ſelf. And any peece diſcharged diuerſe times & not ſponged and cleanſed, the ſaid peece will not doe ſuch effect as being ſponged euery time preſently after ſhe is diſcharged.

If the Trunions of any great peece of Ordnance, as Cannon or Culuering, be placed too neere the mouth, then the peece will be ſo weightie at the breech, that ſhee will require the ayde of two or three Gunners to raiſe vp the ſame with leauers, that ſhe may be brought to her marke; therefore to raiſe the ſame with one mans ſtrength, ſo farre as another may coyne the peece to ſhoote at any marke aſsigned, lay ſome ſmall coyne or peece of timber cut wedgwiſe, on the ſide of the ſtocke or carriage of the peece, that may reach in height with-

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in 2. or 3. inches of the loweſt part of the mettall of the breech of the peece, and putting in your leauer or hand-ſpike as neare the end of the breech as you can, between the ſaid peece of timber & the mettall of the peece, you may raiſe the peece at your pleaſure, ſo as another may coyne the ſame to lay her to any marke aſſigned: & the longer your leauer is, and the leaſt part of the end ther-of that you put vnder the peece, the more weight a great deale you ſhall raiſe vp. Alſo by thruſting a ſtrong leuer into the mouth of the peece, weighing the ſame downe at the furtheſt end thereof, you ſhall weigh or raiſe vp a great weight; and the longer the leauer is, the more weight ſhall you counterpoiſe.

If being in ſeruice, you are like to leeſe your Ordinance, and would rather breake or burſt the ſame in peeces than the enemie ſhould haue aduantage thereof, you may eaſily burſt any peece with her common charge of powder, or with leſſe powder than her common charge, as thus: after you haue put home your powder, make a cloſe wadde as hard as euer you can thruſt in after the ſame, and then take an iron bullet half an inch or more lower than the diameter of the concaue of the peece, and put the ſame home cloſe to the ſayd wad, and vnder the ſaid bullet driue in a wedge or taper peece of iron of fourteene or ſixteene inches in length, made ſmooth and ſmall at the one end, and great at the other, almoſt the height of the bullet, and giuing fire with a traine, the bullet will runne vpon the ſame wedge, and hauing no paſſage by reaſon the ſayd wedge doth ſtop the way thereof, the peece perforce muſt breake in peeces: or you may burſt any peece with her cõmon charge in pouder at any part thereof, in thruſting

sting her mouth into water to that part you would haue broken, & giuing fire by some traine, the peece wil burst at that part without the superficies of the water. The like may be done as some hold opinion in thrusting the peece mouth into a hole made three or foure foot deep into the earth, ramming the earth close about the same, so as no ayre may passe out at the peece mouth: or laying the peece vpon the ground vpon some pieces of timber laid vnder the forepart and hinder part thereof, and making a hollow place vnder the mids thereof, make therein a good fire, and with a paire of bellowes make the peece thorough hote, and with a sledge or great hammer striking the peece in the mids, the middle part of the peece lying hollow, you may easily break the same.

If you would foretell whether any peece of Ordnance will shoote short or ouer anie marke appointed, standing on any side of and from the same peece, and not beholding the visuall line how the peece is layd to the marke, by hauing tried and seene the fall of the bullet, the first shot is an easie matter to shew whether the said peece shall shoot short or ouer any other time, being loaden euery time alike (as thus:) before the peece bee discharged the first time, set vp a laueling, Halbard, or anie streight staffe, directly before the mouth of the peece, and on the same make a priuie marke hard by the vpper or highest part of the mettall, and when the peece is brought to the same platforme againe, and laid to her marke, and hath her length giuen her to reach the mark, before the Gunner giue fire, set vp the staffe againe in the same place, or cause another to set the same vp, and if the highest part of the mettall at the peece mouth

be

be eleuate aboue the ſaid marke on the ſtaffe (which you may eſpy a prettie diſtance from the peece) then the ſaid peece will out-ſhoot the firſt ſhot: but if the vpper part of the mettall at the mouth be vnder the ſaid marke on the ſtaffe, then the peece will ſhoot ſhort of the other ſhot, being loaden with one like quantitie of powder and bullet.

If you would annoy the enemie, and can come to ſerue vnder them without ſuſpicion, and would poiſon their Ordnance, or anie peece thereof, ſo as the ſame ſhould not readily be made to ſhoot, watch a fit time, and poure a little hote oyle thorough a ſmall tunnell into the touch-hole of the peece, the peece mouth a little imbaſed; or raiſing her mouth a little, powre in a little water or other liquor thereat, the which will ſoake thorow the wad into the powder, ſo as the ſame will not fire, or elſe cloying vp the touch-hole with nayles driuen to the head, you may for a ſeaſon hinder the ſame from ſhooting, to the great anoyance of the enemy, and furtherance of your friends, they hauing ſome priuie warning thereof: the chiefe and readieſt way if a peece be poiſoned, is, to draw the ſame, or if the touch-hole be cloyed vp, is to make a traine in at the peece mouth to the chamber where her loading lyeth, and ſo recharging her, it will blow out the ſame, or elſe it muſt perforce be drilled out.

The Platforme whereon your Ordnance is planted in ſeruice, ought to bee ſtored with ſtrong woodden plankes of timber, or paued with broad ſmooth ſtones, layed cloſe together, no higher in one place than in another, but flat and plaine on the ſuperficies thereof, for the wheeles and carriage to make their reuers vpon:

for if the platforme bee not made, the wheeles in often reuerſing will ſo ſinke into the ground, that the peeces without great trouble and more ſtrength of men, will not be brought to their right platforme againe; eſpecially after moiſt weather, the ground being wet before: and the peece ſhall ſometimes ſhoot amiſſe, by reaſon the one wheele will ſometimes ſinke deeper than the other. The platforme behinde the carriage would bee made a little higher than before; ſo ſhall the Gunners with more eaſe a great deale bring the peece to her true platforme after ſhe is reuerſed.

If you would ſee whether the peece you are to ſerue with be cleane without flawes, hony combs, or crackes, then turning her mouth towards the ſun, being vnloaden, with a looking-glaſſe you may caſt the beame of the ſunne into the concaue of the peece: or if the ſunne doe not ſhine, with a lighted candle put on the end of a clouen ſtick you may alſo ſee the ſame: but if you feare that ſhee hath ſome cracke, blow her with a quarter or halfe of her loading in powder, and preſently ſtop her mouth with ſome cloth or other thing, that no ſmoake iſſue out, cauſing another to doe the like at the touch-hole: and if there be any crack in the peece, the ſmoake will iſſue out thereat. Alſo you may perceiue if a peece be without cracke or flawes, in ſtriking vpon the ſame with ſome iron toole; & if the peece be without crack, ſhee will haue a cleere and ſharp ſound being vnloaden, otherwiſe ſhe will haue a harſh or dull ſound.

Any Gunner skilfull and experienced in the Art, may diſpart any great peece ſeuen ſeuerall wayes, but the readieſt and eaſieſt way is to thruſt your priming yron into the touch-hole of the peece, downe to the low-

eſt

eſt part of the concaue of the peece, and with your knife make a marke on the ſaid priming yron, iuſt with the height of the vtmoſt part or higheſt part of the mettall there. Then draw out the ſame priming yron, ſetting the ſame vpright at the mouth of the peece, ſo as the loweſt end of the ſaid priming yron touch the loweſt part of the concaue there alſo, & hard by the vpper part of the mettall at the mouth of the peece with your knife make another marke on the ſaid priming iron, the diſtance betweene thoſe two markes is the true diſparture of that peece.

To anie one or moe peeces of Ordnance of like length and height, that ſhooteth one quantitie of one like powder and bullet, may be made a preciſe table of randons: but a thing vnpoſsible to make one perfect table of randons to ſeuerall peeces of contrarie length and height, diſcharged with one like or vnlike powder and bullet, although diuerſe authors haue affirmed the ſame may be done, and haue giuen out rules thereof: for the variable length of the peeces, the differing weights of the bullets, and the ſundry forces of diuers kindes of powder, muſt and will alter in each of theſe caſes.

By experimenting diuerſe ſhots out of anie one or moe peeces of Ordnance, of like length and height, diſcharged with one quantitie of one like powder and bullet, I could artificially deſcribe how to make an inſtrument, which ſet vpon the breech of the peece, the viſuall line thereof ſhould ſhew what length the ſaid peece requireth to reach any marke within the vtmoſt randon of the ſaid peece, as alſo ſhould ſhew the number of degrees the ſaid peece is eleuated at, and how farre the

ſaid peece would conuey her bullet at any degree of the randon, or what diſtance any mark is different from the peece, and how much higher or lower the ſaid marke is than the point blanke of the ſaid peece, the ſaid peece loaden at euery time with one like quantitie of one like powder, wad and bullet, and of like temper: but foraſmuch as the ſame will not hold in all peeces of contrary length & height, neither in any one peece of Ordnance diſcharged with her due loading of diuerſe kindes of powder, it were a thing not conuenient to ſhew the reaſons therof, for that the ſame requireth a long diſcourſe, and would be to no great purpoſe, vnleſſe the ſame might be a generall rule for all peeces, of what length and height ſoeuer.

You may diſcharge any peece of Ordnance by the beame of the ſunne a pretty diſtance from the ſame, the ſunne bright ſhining, and the day cleere and hote, in taking a broad bright baſon, ſetting the ſame ſo on the ſide of the carriage of the peece againſt the touch-hole, that it may ſtrike the reflex of the ſunne beame backe vpon a traine of fine powder layde vpon and about the touch-hole of the peece, in the midſt whereof lay a little fine lint dipped in molten brimſtone, and on the ſame a cryſtall ſtone; and ſtanding thirty or forty yards from the ſame (or further, if you thinke good) by the ayde of three or foure glaſſes well ſteeled, you may caſt the beame of the ſunne directly againſt the centre of the baſon, which will ſo multiply the heate, that it will preſently fire the traine, and ſo diſcharge the peece. Or you may giue fire to any peece of Ordnance with a burning glaſſe; but then you muſt be neere to the peece, which will be perillous, for feare of the reuerſe of the wheele,

except

except you make a traine, and ſo drawing the beame of the ſunne into a point like a pin head through the center of the glaſſe, you ſhall ſo multiply the heate, that it will preſently giue fire to the peece. I reade that *Archimedes* by his skill in Geometry and in the Art Perſpective, did from off the wals of Siracuſa (the Citie being beſieged by the Romanes) fire their Nauie riding in the roade without, onely by the ayde of glaſſes; as alſo diuerſe of our owne country-men by the aide of glaſſes haue experimented many notable and ſtrange concluſions, to their euerlaſting fame.

You may alſo with a quart or pottle of any liquor, as wine, water, ale, or beere, diſcharge any peece of Ordnance, in putting into the touch-hole of the peece the end of a peece of match of a yard or fiue quarters long, well ſoaked in moulten brimſtone, the peece being well primed: and ſetting or making faſt to the ſide of the carriage of the peece, any little halfe firkin or woodden veſſell that will hold a gallon or pottle of liquor, filling the ſame halfe full of lymeſtone new burnt and vnquenched, & take the lightneſt & whiteſt ſtones you can finde (for thoſe are beſt burnt:) then take three or foure of thoſe ſtones, and beate the ſame into fine powder, and mixe with three or foure handfuls of the ſame, as much powder and brimſtone beaten verie fine, laying the ſame amids the veſſell vpon the ſtones, rowling the other end of the match in that receipt, and then fill vp the veſſell with other like ſtones, powring vpon the ſame as much liquor aforeſaid as would fill halfe the tub: the which will melt the ſtones into duſt, and drink vp all the liquor, and with the heat therof will preſently fire the brimſtone, which kindling the match, will diſcharge

charge the peece: and if you make the ſaid liquor ſeething hote, and poure it into the veſſell, it will ſo worke therein, that if the veſſell be not all the better girded, it will burſt it in peeces.

If in ſeruice, or at any other time, you haue occaſion to ſhoot diuers ſhots in one or mo peeces, the day being verie windie, ſo that it bloweth away the priming powder laid about the touch-hole of the peece, to preuent that inconuenience, if you take a little tough clay, working the ſame wel in your hand, and laying the ſame vpon the mettall of the peece on the windie ſide, in maner of a circle, one or two inches from the touch-hole, about one inch height, it wil hinder the wind from blowing the priming powder away, ſo that you may giue fire at pleaſure.

Any peece of Ordnance being diſcharged in the night, the report or roare thereof will be heard further than if ſhee had been diſcharged in the day, the weather of like calmneſſe: & the report wil ſound further down the winde than againſt the ſame, and further on the ſea than on the land, the ayre quiet and the ſea calme. Alſo if you make a hole in the ground fiue or ſix inches deep, and lay your eare cloſe thereto, you ſhall heare the report of any peece of Ordnance diſcharged from farre more perfectly than ſtanding or walking: by experience, it hath beene often tryed, that the ſound of the Canons diſcharged at the ſiege of diuerſe Holds, hath bin heard verie neere fortie miles.

Some Gunners hold opinion, that the reuerſe of anie peece of Ordnance diſcharged, is not before the fire be cleane expulſed out of the concaue of the peece into the open aire: but therin they erre, for experience ſheweth that

that the peece and cartiage beginneth to recoyle in that moment, assoone as euer the powder fired within the peece, beginneth to thrust it selfe out, the violent expulsiue motion whereof striuing forward, causeth the peece to recoyle, but the rore or report of the peece discharged, is not before the fire be expulsed out of the peece. Also some hold opinion, that the force of the fire departing from the peece, causeth the mettall to quiuer or shake: and to assure themselues, they haue for tryall clapt to the bottome of a glasse a little quantitie of wax or pitch, and filling the glasse with water, set the same vpon the highest part of the mettall, about the middle of the peece; and because the same hath broken in shiuers or fallen, they thinke their opinion is strong. But my opinion is contrary; for if the mettal of the peece at her discharge doe any whit quiuer or shake, the peece would eyther burst in shiuers or rent it selfe: for I hold that it is the very ayre or violent blast proceeding from the fire, eyther out of the mouth of the peece, or touch-hole, or both, and withall the sudden reuerse of the peece, that doth cause the thing so set vpon the vpper face of the mettall, to burst or fall off: and for the better triall hereof, I asked the opinion of a souldier, who for a trespasse committed was enioyned to ride the Canon, who confidently affirmed, he could perceiue no quiuering of the mettall of the peece, but that the ayre which issued out of the mouth and touch-hole of the peece did somewhat astonish and shake him.

A ball or bullet of wild-fire shot out of a Chamber or Morter peece, hauing one or mo vents made vpon anie one part thereof to kindle the ball, although for a little motion the said vents burneth from you in the range

thereof, by reaſon they are firſt fired, and ſtand neereſt to the peece mouth before the deliuerie thereof; yet for the greater part of the range the ball will turne and burne with the ſaid vents towards you; as by experimenting the ſame you may ſee: for reaſon teacheth, that any ſolid thing violently driuen, flyeth with that part formoſt that is moſt ponderous and weightie, which in this caſe muſt needs be that part of the ball vnburnt, or which is not vented.

A ball of wilde-fire diſcharged out of any peece of Ordnance, hauing but one vent, the ſwifter that the receit is in burning, the further it wil range, the peece being preſently diſcharged as the bal is fired: and the ſlower the receit is, the leſſe diſtance will the range be: and any ball hauing but one vent, will range further and burne longer than hauing diuers vents.

A ball of wild-fire made to burne in the water, being fired and throwne therein, that part will appeare firſt aboue the water that is lighteſt (to wit) that part wherein the vent is, the which ball will not burne perfectly aboue the ſuperficies of the water, vntill the $\frac{1}{3}$ thereof be burnt and emptied, and ſo beeing filled with ayre doth cauſe the other part to ſwimme and burne aboue the water.

A ball of wilde-fire made neuer ſo artificially ſhot out of a morter, chamber, or other great peece of Ordinance, the peece hauing her full loading in powder, that is vſed to giue her in ſhooting a bullet of mettall, will cauſe the ſaid ball to burſt in peeces, and therefore the ſaid peece muſt bee loaden with a proportionall charge in powder to the weight of the ball, which will not be aboue $\frac{1}{3}$ the weight of the ordinarie charge vſed

to ſhoot a bullet of mettall.

A ball of wild-fire diſcharged out of any peece of great Ordinance, beeing vented or bored through croſſe-wiſe, and primed full of powder to take fire, although the flame of the fire in the burning of the ſaid ball iſſue out at euery end of the ſaid vents, that, is foure ſeuerall waies, yet in the motion or range thereof, the greateſt part of the flame and fire will iſſue out but at one or at two vents at the moſt, which will bee thoſe vents in that part of the ball that is towards the peece; for the violent mouing of the bal through the aire, doth cauſe the flame to ſhew it ſelfe, and to burne moſt on the contrary part againſt which it flieth: the which flame will ſhew it ſelfe as it were a taile, or traine following the ball in his motion. And it is to be conſidered, that in ſhooting any peece of Ordinance with a fire ball, the peece would be loaden with leſſe than halfe her ordinary charge in powder, or with the one halfe at the moſt, that is, with one ladle full of powder, the which put gently home with the tampion on the end of your rammer ſtaffe, put in the ball cloſe to the powder, priming the ſame well before you put it in, and after the ball put in a handfull of powder cloſe to the ball, ſo ſhall you be ſure the ſame will take fire, and not burſt in the flight or range being well wolled and marted.

The receits wherewith bals of wild-fire or other fire-workes are made being ſlow, may be made more ſtrong and to burne more furiouſly, by adding a little bruized powder to the receits, working the ſame well together: and any fire-work whoſe receits bee too forcible in burning, may be made more ſlow, by adding a quantity of ſome liquide receit thereunto.

A ball or bullet of wilde-fire diſcharged out of any peece of Ordnance in a cleere day, at any marke within the reach of the peece, cannot be diſcerned in his range, nor ſeen to burn before it light on the ground. And any ball of fire-worke diſcharged out of any peece of Ordnance at any mark in the darke night, may be perceiued by the eye all the range thereof: and the more darker the night is that the ſame is ſo diſcharged, the better you may diſcerne the ſame: but in the beginning of the range, the eye is not able to diſcerne it ſo perfectly as in the latter part thereof; neyther doth the ball burne ſo forcibly, nor giue ſuch light in his ſwift motion (that is, in the firſt part of the range) as in the latter part of his motion, when it declineth towards the ground.

If you take Arſnicke and Sulphur, of each like quantitie, and beat the ſame very fine, and then boyle the ſame in a couered pot, and then kindle the ſame with a candle, letting no other light be ſeen, the ſtanders about the ſame will ſeeme monſtrous ſtrange one to another.

Or if you take *Aqua compoſita* and Salt, and pound the ſame together, and fire the ſame in the darke where no other light may be ſeene, the beholders will ſeeme as they were dead.

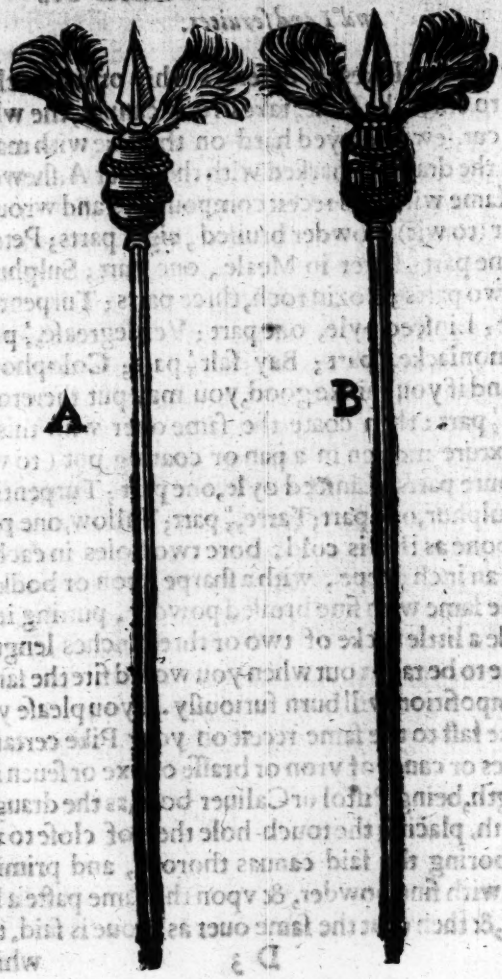
I read in *Albertus Magnus*, and diuers other ſuch Authors, how to make ſtrange lights: ſuch as would praćtiſe the ſame, may haue recourſe to their works.

Deuices

Deuiſes of certaine ſeruiceable Fire-workes, verie neceſſarie to be vſed both for Sea and Land ſeruices.

TO arme Pikes to defend a Ship or a breach, or to enter the ſame, take ſtrong canuas, the which cut, ſewed & tyed hard on the pike with marlin cord, as the draught marked with the letter A. ſheweth; fill the ſame with this receit compounded and wrought together (to wit) Powder bruiſed, eight parts; Peter in Roch, one part; Peter in Meale, one part; Sulphur in Meale, two parts; Rozin roch, three parts; Turpentine, one part; Linſeed oyle, one part; Verdegreaſe, $\frac{1}{2}$ part; Bole armoniacke, $\frac{1}{3}$ part; Bay ſalt $\frac{1}{3}$ part; Colophonia, $\frac{1}{6}$ part: and if you thinke good, you may put thereto of Arſnick $\frac{1}{8}$ part: then coate the ſame ouer with this liquid mixture molten in a pan or coating pot (to wit) Pitch, foure parts; Linſeed oyle, one part; Turpentine, $\frac{1}{7}$ part; Sulphur, one part; Tarre, $\frac{1}{3}$ part; Tallow, one part. And aſſoone as this is cold, bore two holes in each of the ſame an inch deepe, with a ſharpe yron or bodkin, filling the ſame with fine bruiſed powder, putting in euerie hole a little ſticke of two or three inches length, which are to be taken out when you would fire the ſame. This compoſition will burn furiouſly. If you pleaſe you may make faſt to the ſame receit on your Pike certaine light pipes or canes of yron or braſſe of ſixe or ſeuen inches length, being Piſtol or Caliuer bore, as the draught B. ſheweth, placing the touch-hole thereof cloſe to the canuas, boring the ſaid canuas thorow, and priming the ſame with fine powder, & vpon the ſame paſte a little paper, & then coat the ſame ouer as aboue is ſaid, the

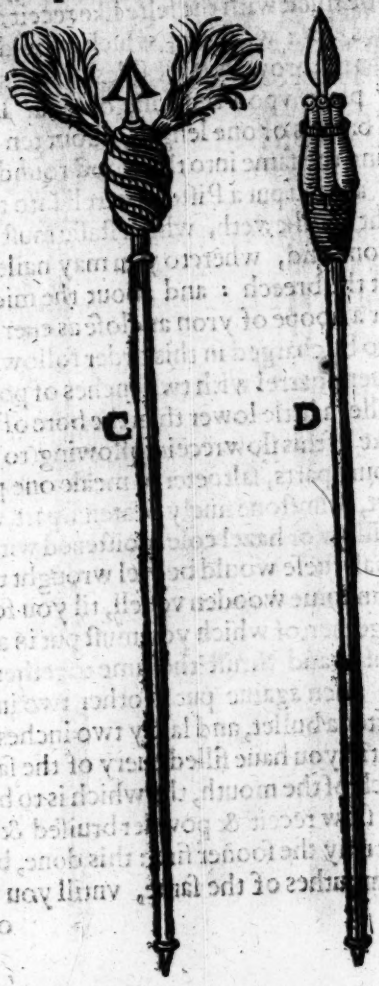
which charged with powder and bullet will doe great execution in a throng, either to offend or defend.



You may arme a Dart, a Iauelin, Partizan, or ſuch like weapon, to do excellent good ſeruice, being in the hand of a valiant ſouldier, as you ſee the figure ſhewe: the which may be filled with the ſelfe like receit as is taught to arme pikes with wild-fire, which would be a very good weapon to throw into the ſides or ſailes of ſhips; or you may place vpon the ſtaffe of your Iauelin certaine Piſtoll barrels of one length, about ten or twelue inches, letting the ſame into the wood round about the ſtaffe a little, as you put a Piſtoll barrell into the ſtocke, as the draught D. ſheweth, which ſtaffe muſt haue ſubſtance at the one end, whereto you may naile the ſame barrels faſt at the breech: and about the midſt of the ſame put ouer a hoope of yron as cloſe as euer you can, the which is to be charged in this order following, viz. firſt charge euery barrel with two inches of powder, after put in a bullet a little lower than the bore of the ſame peece; then take of this ſlow receit following (to wit) bruſed powder foure parts, ſaltpeter in meale one part, linſeed oile 1. part, brimſtone finely beaten 1. part, varniſh 1 part, and of willow or hazel cole moiſtened with a little venegar 1. part: all theſe would be wel wrought together with the hand in ſome wooden veſſell, til you feele that it will cling together, of which you muſt put in after the bullet two inches, and thruſt the ſame together with a rammer ſtick: then againe put in other two inches of powder, and after a bullet, and laſtly two inches of this ſlow receit, vntill you haue filled euery of the ſaid barrels within $\frac{1}{3}$ inch of the mouth, the which is to be filled vp with the ſaid ſlow receit & powder bruiſed & mixed together, that it may the ſooner fire: this done, binde a paper ouer the mouthes of the ſame, vntill you would

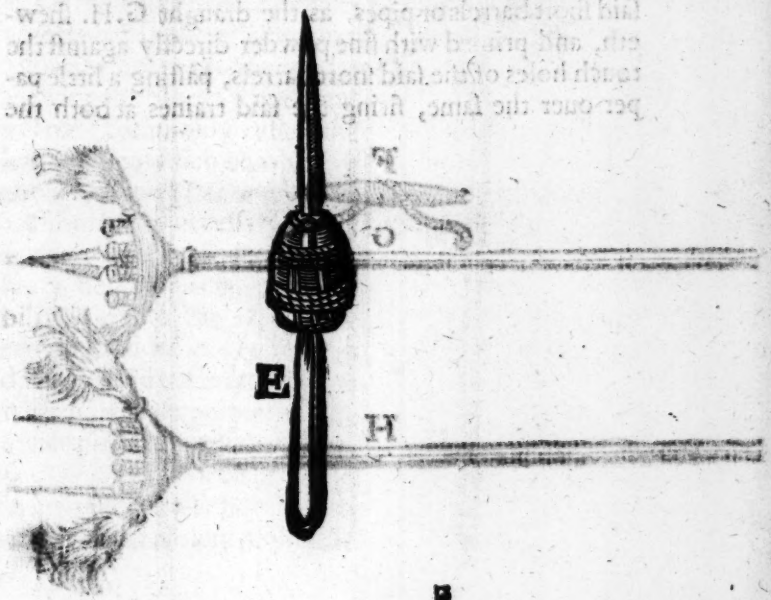
occupy

occupie them, and giuing fire to any one of the same, it will fire all the other, and euery one will discharge three or foure shots a peece, one after another, to the hurt of

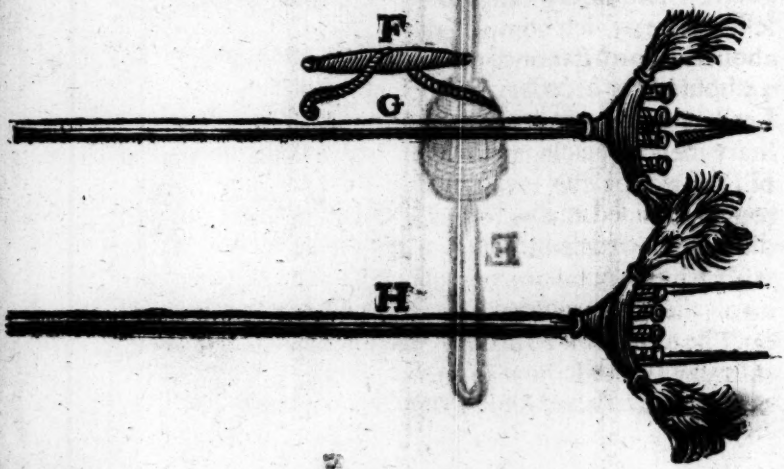


the enemie being vſed in ſeruice either to offend or defend, and to the pleaſure of the beholders, being vſed in triumph with bullets of receit rolled in fine tow, and coated with brimſtone.

If you would defend ſome narrow roome, or would enter vp a paire of ſtairs, where you cannot weild a long weapon, you may make a logget, whoſe ſtaffe ſhal bee but three or foure foote long: arming the ſame with the like receit as I haue ſhewed to arme pikes, whereon you may place certaine pipes of braſſe or iron charged as afore is taught: & if you wil you may put into the end of the ſtaffe a Rapier blade with a skrew to take off and on at your pleaſure, as the draught E. hereunder ſheweth.



Alſo you may arme a Partezan, Iauelin, or Fork with fire-worke, to offend or defend a breach, ſhip, or any place of defence, and to ſhoot euery of them ſeuen or eight Piſtol or Caliuer bullets; in nailing a plate of iron croſſe the pike or point of the ſaid Iauelin, or betweene the graines of the Fork, piercing certain holes through the ſame, vnto which with a ſtrong wyer you may make faſt on either ſide ſo many pipes of iron of 7. or 8. inches length as you think conuenient to fix vpon either or any of the ſaid weapons; & charging the ſame with powder, bullet, and wad, you may cauſe the ſame to fire one after another, in filling a role of canuas ſewed together as the draught F. ſheweth, with ſlow receit and coated as afore is taught, the which placed arteficially vpon the ſaid ſhort barrels or pipes, as the draught G.H. ſheweth, and primed with fine powder directly againſt the touch holes of the ſaid ſhort barrels, paſting a little paper ouer the ſame, firing the ſaid traines at both the



ends, which as they burne ſhall ſtill diſcharge the ſhort peeces one after another, to the great good of the defendant.

To offend or defend any narrow paſſage, or for diuers other militarie ſeruices, you may place vpon the point or pike of any Halbard a deuiſe of fire-worke, in maner as is taught to arme pikes, made of the ſame like receit, & coated with the ſelf like coating: and if you pleaſe you may make faſt therto half a dozen or mo ſhort pipes, like Piſtoll barrels, of 7. or 8 inches length, loden with powder and bullet as this draught ſheweth.

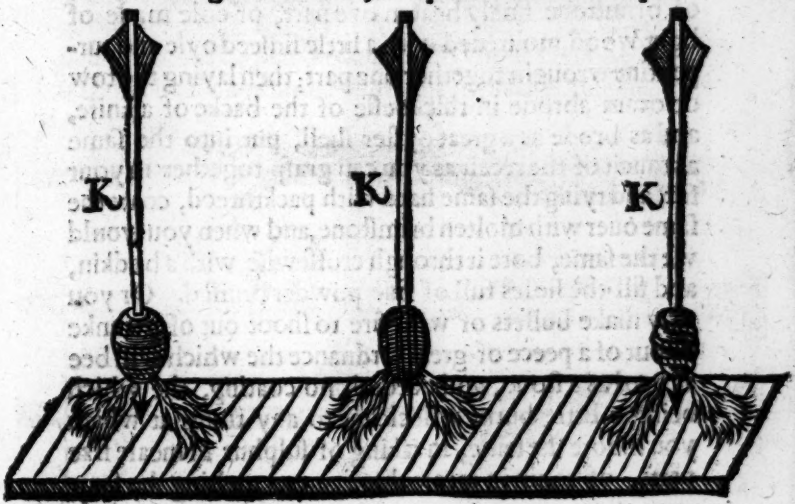
Or you may make a ſeruiceable halbard by which you may know the houre of the night, by viewing the North ſtarre, and guards (commonly called the leſſer Beare) which compaſſeth about the north ſtar once euery 24. hours, very neceſſary for all Leaders or Cõmanders of military men, by placing vpon the bill or axe of the Halbard a roundel diuided into 24. equall diuiſions, and traced and drawn with an index or pointer hauing a hole pierced through the center. The order how to make the inſtrument, as alſo how to find out any houre in any night that

the ſaid ſtarres may bee ſeene, you may learne in the ſeuenteenth Chapter of the Art of Nauigation, written by *Martin Curtis*, who ſheweth the ſame in ſuch a plaine and eaſie manner, that any vnlearned man hauing a ſharpe wit may vnderſtand the ſame.

To burne the ſailes of ſhips a prettie diſtance off, or to fire thatched houſes, corne-ſtacks, or any combuſtible matter apt to burn, when as you cannot come to the ſame, it is good to make certaine ſtrong bowes, to bend either with a rack or gaſſel, or otherwiſe, and to ſhoot out of the ſame ſtrong arrowes armed with wild-fire, & headed as the draught I, ſheweth: the compoſition is to be made as is taught to arme Pikes with fire-work, which arrowes may do great good for diuers ſeruices.

To burne bridges, woodden gates, &c. or to doe diuers other militarie ſeruices, if you can come to annoint the ſame with ſome ſuch liquid compoſition as I haue ſhewed for the coating of fire-workes, melting in the ſame a good quantitie of bruiſed brimſtone, and ſticking in the ſame arrowes of wild-fire made in proportion as the draught K, ſheweth, the which may be made of the ſelfe like receits, as is taught to arme pikes with fire-workes, which will vndoubtedly ſet the ſame a fire, for the receit is ſo forcible that it will burne in the water.

To charge trunkes to ſhoot little bals of wild-fire, either to offend or defend, you muſt charge the ſame with two inches of good powder, and then with a bal of wild-fire a little lower than the concaue of the trunke, bored through croſſewiſe, and primed full of fine pow-



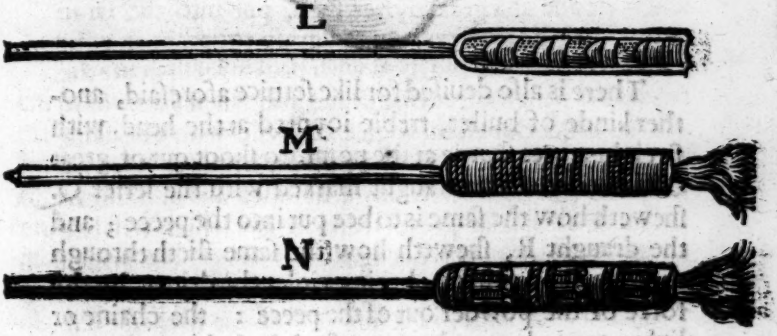
der,

der, and laſtly with two inches of ſlow receit, and then againe with powder, and then a ball of ſlow receit, vntill you haue filled the ſame within ¼ of an inch of the mouth, which would be filled vp with fine powder and receit mixed together. The order how to charge a trunk appeareth by the draught L. the draught M. ſheweth the proportion of a trunke already charged and fired, and the draught N. ſheweth how certaine pipes of braſſe or yron may bee placed on a trunke, which beeing loaden each of them with a Piſtoll or Caliuer charge of powder and bullet, will do great execution.

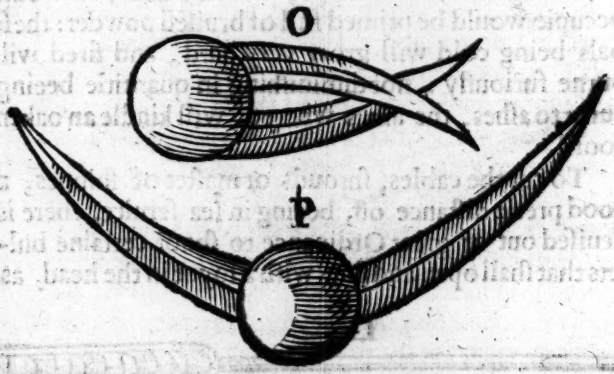
The bullet or ball of wild-fire, or button, as ſome Gunners terme it, would be made in this manner. Take vntwiſted match, tow, or hempe, the which would bee moiſtened in *Aqua vitæ*, or ſod in ſaltpeter water, then take of bruiſed powder ſixe parts, of ſaltpeter one part, of brimſtone finely beaten one part, of cole made of light wood, moiſtened with a little linſeed oyle and turpentine wrought together one part; then laying the tow or ocam abrode in thickneſſe of the backe of a knife, and as brode as a great oyſter ſhell, put into the ſame as much of the receit as you can graſp together in your fiſt, and tying the ſame hard with packthreed, coate the ſame ouer with molten brimſtone, and when you would vſe the ſame, bore it through croſſewiſe with a bodkin, and fill the holes full of fine powder bruiſed. Or you may make bullets of wild-fire to ſhoot out of a trunke or out of a peece of great Ordnance the which will bee as hard as a ſtone, and needeth no coating, the which being a little burnt will cleaue to any thing at which you ſhoote the ſame, in taking of ſulphur in meale ſixe parts, of rozin in meale three parts, melting the ſame

in some pot or pan ouer a slow fire, then take of stone pitch one part, of hard waxe one part, of tarre ¼ part, of *Aqua vitæ* ½ part, of linseed oyle ½ part, of verdegreese ¼ part, of camphire ⅛ part, melting all these together likewise, and stirre into the same of Peter in meale two parts; and taking the same from the fire, put therin foure parts of bruised powder, working the same well together in your hands, and rol the same round, of the greatnesse you meane to make the balles of, boring two holes through the same acrosse, which when you would occupie, would be primed full of bruised powder: these bals being cold will grow very hard, and fired will burne furiously, not diminishing in quantitie beeing burnt to ashes, the ashes whereof will kindle an oaken boord.

To cut the cables, shrouds or mastes of shippes, a good pretie distance off, beeing in sea seruice, there is deuised out of great Ordinance to shoot certaine bullets that shall open and shut with a ioynt in the head, as

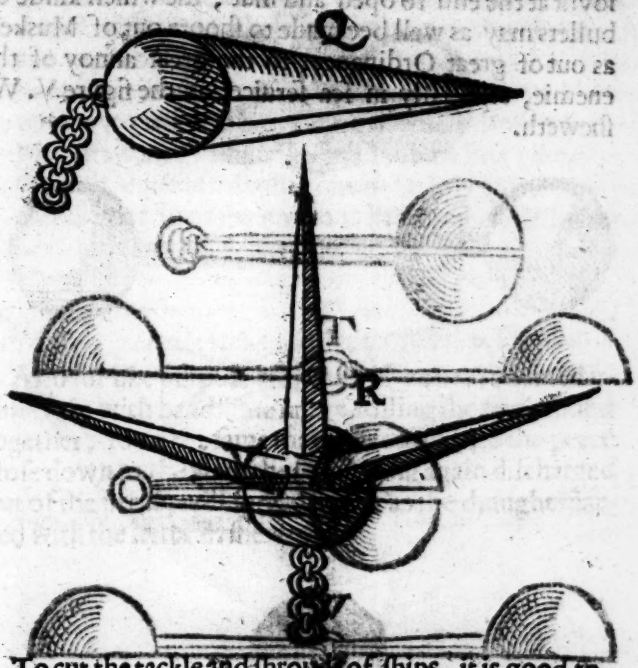


you ſee a paire of compaſſes, the armes or legs whereof are made in proportion to the blade of a knife, taperwiſe, and bowing ſharpe towards the point as the draught hereunder ſheweth, where the draught O. ſheweth how the ſame is to bee put into the peece after the powder and wad, and the draught P, ſheweth how the ſame in his violent motion flieth through the ayre like a ſythe, beeing ſhot out of any peece of great Ordinance.



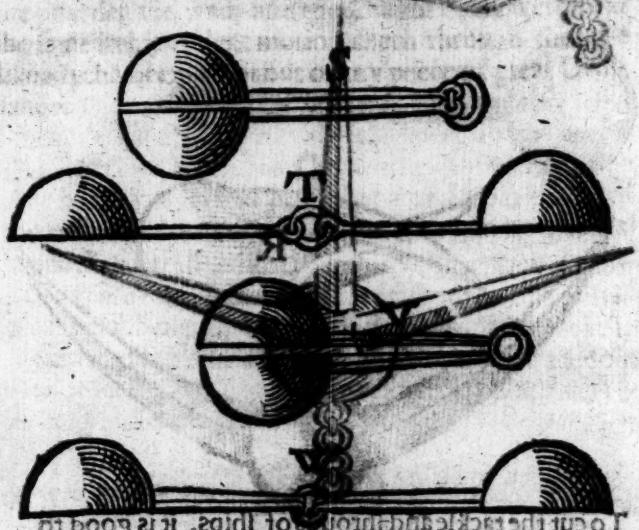
There is alſo deuiſed for like ſeruice aforeſaid, another kinde of bullet, treble ioynted at the head, with ſtreight armes ſharpe at the point, to ſhoot out of great Ordinance: the draught marked with the letter Q. ſheweth how the ſame is to bee put into the peece; and the draught R, ſheweth how the ſame flieth through the ayre like a galtrop, beeing violently driuen by the force of the powder out of the peece: the chaine or linkes are to keepe the ſame ſtreight in his motion or range.

To



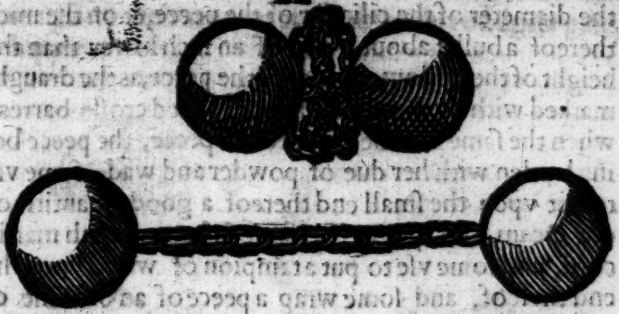
To cut the tackle and shrouds of ships, it is good to caſt halfe bullets of iron or lead; vnto euery of which make faſt a barre of yron, wrought either three ſquare or foure ſquare, of the greatneſſe of a mans finger, about fourteene or ſixteene inches length, with a loope at the end, vnto which a ring of iron is to be put, that the ſame may cloſe and ſhut as the draught S. ſheweth, ſhewing alſo how you muſt put the ſame into the peece: and the draught T. ſheweth how the ſame ſtieth in his mouing through the ayre. Or to the ſaid halfe bullets you may make bars in proportion of a knife blade, with a round

ioynt at the end to open and shut, the which kinde of bullets may as well be made to shoote out of Muskets as out of great Ordinance, to the great annoy of the enemie, especially in sea-services, as the figure V. W. sheweth.



Also, to cut the tackle of shippes, or to doe many other good services, either with Musket or other peece of great Ordinance, it is good to chaine together two bullets in manner as the draught hereunder sheweth, whose the letter X. sheweth how the same is to be put into the peece, and the letter Y. sheweth how the same flyeth through the ayre, being discharged out of any peece of great Ordinance, or out of any Musket.

X



Y

Alſo for like purpoſe aforeſaid, if you take a ſmall yron chain with handſome linkes, rolling the ſame round together, ſo as the ſame may goe eaſily into the peece cloſe down to the wad, the ſame being again diſcharged out of the peece, will ſpread it ſelfe as the draught marked with the letter Z. ſheweth.

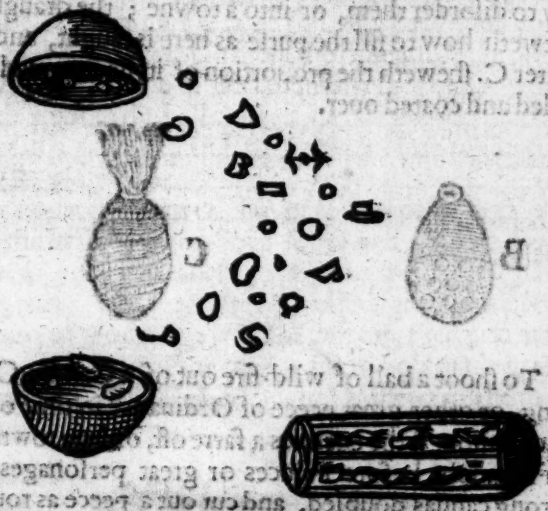
Z

There is alſo vſed to cut the maſtes or ſhrouds of ſhips, or to boudge the ſame, &c. to charge great Ordinance with bullets of yron, having a great ſquare barre through the ſame of two foote length or there-

bouts, ſharp at the one end & round at the other, about ½ the diameter of the cilinder of the peece, & on the mids thereof a bullet about ¼ part of an inch lower than the height of the hollow cilinder of the peece, as the draught marked with A, ſheweth, theſe are called croſſe-barres: when the ſame is to be put into the peece, the peece being loaden with her due of powder and wad, ſome vſe to put vpon the ſmall end thereof a good quantitie of old Ocam, wrapping the ſame faſt about with marlin cord, and ſome vſe to put a tampion of wood vpon the end thereof, and ſome wrap a peece of an old laine or other old cloth faſt vpon the end of the bar, and ſo diſcharge the ſame.

Being in ſea ſeruice, if the enemie will needes boord you, and that you intend not to yeeld, it is neceſſarie to haue in ſtore and readineſſe diuers hollow bullets, made of two plates of iron or other mettall, ſo as the one may cloſe round vpon the other like a boxe, the which filled with pebble ſtones, ſquare peeces of yron called dice ſhot, Musket bullets, and ſuch like, and diſcharged out of a murdering peece will do wonderfull hurt: behold the draught enſuing. Or, if you fill caſes of wood made like vnto a lanthorne full of pebble ſtones, dice ſhot, musket bullets, peeces of yron, or ſuch like, diſcharging the ſame out of any peece of great Ordinance

(especially out of a murdering peece) wil do great execution against such as are to enter a breach, a bridge, a gate, a ship, &c.



If you bee to enter a ship or other place where you feare there is some traine laid to blow you vp, you may preuent the same by making certaine purses of canuas filled halfe full of good corne powder, and with eight or tenne firie bullets of an inch or an inch $\frac{1}{2}$ height, such as I haue taught to put in trunkes, and filling the other part of the purse with such slow receit as there is also taught, you may when you thinke good (the receit beeing well fired) throw the same from you, which will burst in peeces after the lighting on the ground, and disperse the said inclosed bullets here and there, which

bullets will burne furiously, and if there bee any traine of powder laid neare, will presently fire the same. The said purses are very good to throw out of hand, or may bee shot out of a morter peece amongst men in battell ray to disorder them, or into a towne; the draught B. sheweth how to fill the purse as here is taught, and the letter C. sheweth the proportion of it beeing made vp, filled and coated ouer.

To shoot a ball of wild-fire out of a Canon, Culuering, or other great peece of Ordinance in time of seruice, amongst the enemies a farre off, or into townes, or in triumphs before Princes or great personages, take strong canuas doubled, and cut out a peece as round as the circumference of a circle, just the height of the diameter of the concaue of the Peece out of which it is to be shot, the which sewed sure round about all saue one inch, fill the same full of this receit following (to wit) powder bruised eight parts, Peter meale two parts, Peter roch one part, rozin roch like pepper cornes two parts, Turpentine ½ part, Linseede oyle one part, Sulphur meale one part, Sulphur roch one part, bole armoniacke ½ part, Verdegreese ¼ part, Colophonia ½ part. All these things mixed in a tray or some such like woodden vessell, and wrought well together

gether with the hand, fill the ſaid ball therewith as hard as you can; then ſewing vp the hole and woolling and marling the ſame well, coate the ſame ouer with molten brimſtone; and with a ſharpe yron a little greater than a bodkin, bore two or three holes croſſe through the ſame ball, priming the ſame full of fine bruiſed powder; and when you would ſhoot the ſame, loade the peece but with ½ quantitie of her common charge in powder, and after put in the ball cloſe to the ſaid powder, and after put in a good handfull of powder cloſe to the ball with the tampion on the end of your rammer ſtaffe, the peece mounted about twelue or fourteene degrees will cauſe the ball to range aboue foure and twentie ſcore paces. If you would haue the ball to make a pleaſant range, mount the peece aboue thirtie degrees; and if the tranſome of the cariage will not ſuffer it, then you may dip the lower end of the cariage into a hole made in the earth for the purpoſe, the draught D, ſheweth the proportion of ſuch a bullet.

To ſhoote a ball of wilde-fire out of a Chamber or Morter peece, you muſt charge the peece with powder according to the proportion of her chamber, and quantitie of the ball or bullet that ſhe is to ſhoot, and according

ding

ding to the diſtance the ball is to range, and then take a cloſe wad as hard as you can put home to the powder, and after put in the ſaid ball, firſt making three or foure vents therein within the compaſſe of a ſhilling, an inch or two inches deepe with a bodkin, priming the ſame with fine bruiſed powder, and be ſure when you put the ſame into the peece, that the vents be vppermoſt next to the mouth of the peece, iuſt in the center or midſt of the concaue thereof, then take a peece of gunmatch, or a little hay twiſted with your hand, and after the ball is in the peece as is ſaid, put the ſame round about the circumference of the bullet, & with a ſmall woodden wedge beat the ſame cloſe round about the bal, between the ſaid bal and the mettal of the peece, ſo as no powder fal into the peece, wherby the ſame might be diſcharged before the ſaid bal were wel kindled with the traine which you are to make at the mouth of the peece. This done, prime the peece well at the touch-hole, laying a little powder on ſome brode ſtone as a train to fire the ſame readily, couering the ſame with ſome cloth til the bal be wel fired, leſt ſome ſpark iſſuing from the bal, fire the peece too ſoon. And when you ſee the ball is wel kindled, take away the cloth, and giue fire to the train at the touch-hole, and ſo ſhooting the ſame amongſt men in battell ray, or into a town amongſt thatched houſes, or corn-ſtacks, this kind of fire-work wil do excellent good ſeruice: the letter E, ſheweth the proportion of ſuch a bullet to be ſhot out of a Chamber or Morter peece: but if you be to ſhoot out of your Morter or Chamber peece bullets of ſtone or of mettall into ſome Hold or Town, then you need doe no more but onely loading the peece with her charge of powder, wad and bullet, giuing fire to the traine at the touch-hole,

touch-hole, and giuing the peece her due length, she will performe your wished desire.

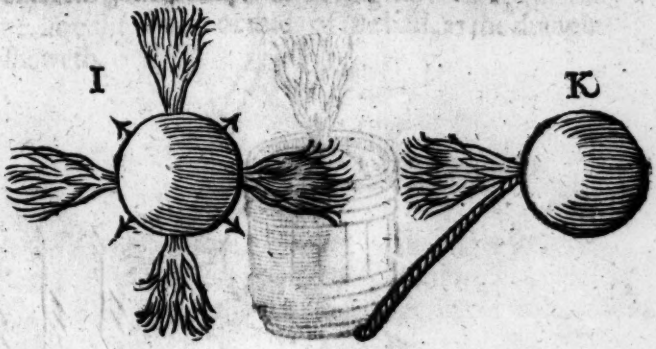
To make balls of wild-fire to shoot out of a Chamber or morter peece, that being recharged shal stick in wodden gates, ship sides, or such like, make of those balls I haue taught to shoot out of a Canon or Culuering, the which filled as ful & as hard as you can, with the like receit as there is taught, and woolled well & coated ouer, make certaine peeces of yron sharpe at the point of two inches length, with a skrew of ½ of an inch long at the one end to screw into the bal, & hard by the same a ioint with a shoulder, that you may at pleasure, put the other end together close to the vtter side of the bal; the which nails or sharpe pieces of iron skrewed in to the shoulder into the ball (the ball being made somthing lower than the concaue of the peece) being discharged out of the peece, will stick in any soft obiect, as wood or such like: for the forcible motion of the bullet or ball, will thrust the said pieces of yron stiffe out in their ioints, so that lighting vpon any resisting obiect (except stone) wil stick in the same: the draught following noted with F, shewes how the same is to be put into the peece, & the letter G, how the ioints do stand themselues in the violent motion the ball discharged out of a chamber or morter peece.

Or you may make bals to throw out of hand into the ſides or ſayles of ſhips of the receit aforeſaid, in skrewing into the ball round about the vtter ſide thereof, certaine pieces of yron, made ſharpe at the ends, like an Adders tongue, as the draught H hereunder ſheweth.

You may alſo make another kinde of fire-ball that ſhall burne furiouſly, and giue a great light, that ſhall ſticke in any reſiſting obiect that you are to throw the

ſame

ſame into, in taking three or foure peeces of yron of like length, made ſharpe at the point, letting the one into the other in the mids, ſo as the one may croſſe the other iuſtly, and taking of gooſe greaſe or ſwines greaſe one part, of tarre ½ part, of pitch two parts, of *Aqua vitæ* ½ part, of linſeed oyle one part, of turpentine one part, of verdegreaſe ½ part, of waxe ½ part, of gumme ½ part, of Saltpeter meale one part, of Sulphur meale one part: melt all theſe together ouer a ſlowe fire, and in that liquid mixture dip a good quantitie of Tow and linnen rags, and after rub the ſame well in bruiſed powder, the which rolled hard round about the peeces of yron aforeſaid, binde the ſame about with ſmall wyer or packthreed, and when you would occupy the ſame, bore two holes croſſe thorow the ſame, filling the ſame with bruiſed powder: the draught I, ſheweth the proportion of ſuch a ball as here is ſpoken of. This kind of fire-ball may be made to ſhoote out of great Ordnance, in making the ſame round, as aboue is ſaid, without the peeces of yron: or you may make of theſe balls to throw with



with hand amongſt men in battell aray, or into ſhips, or you may vſe the ſame in a triumph for pleaſure in tying a cord of ½ long thereunto, as the letter K, ſheweth.

To make a fire-ball to burne in the water, take powder bruiſed ten parts, Peter in meale two parts, Peter roch one part, Sulphur meale three parts, Rozin roch three parts, Turpentine one part, Linſeed oyle one part, Camphire ¼ part, Arſnick ¼ part, Verdegreeſe ¼ part, bole armoniacke ¼ part, cornes of bay ſalt ½ part, filings of yron ½ part, quicke-ſiluer ½ part. All theſe things being well wrought together with the hand in ſome wooden veſſell, double a peece of canuaſſe, & cut out of the ſame a round peece of three inches, or three inches ½ diameter, which being well ſewed fill the ſame with this receit, and binding the ſame ſtrongly about with packethreed, and coating the ſame ouer with molten pitch, or with the mixture taught to coate pykes of wildefire, make therein but one vent of an inch deepe, priming therein fine bruiſed powder, and put into the hole a little ſticke of two inches length, which when you would occupie you may take out, and letting the ſame

burne a while in your hand, caſt the bal into ſome hogs-head full of water, or into a riuer or pond, and the ſame will come vp to the ſuperficies of the water, and burne furiouſly: the draught laſt before ſheweth the manner thereof.

Or you may make a ball of wild-fire to burne in the water in this maner: take brimſtone in meale two parts, and melt the ſame ouer a ſlow fire, and therin put of ſalt-peter in meale one part, of gum ½ part, of wax ¼ part, and taking this compound from the fire, ſtir into the ſame of bruiſed powder three parts, working the ſame well to-gether, moiſtening the ſame with a little oyle of linſeed or *Aqua vitæ*, and putting this receit into a peece of can-uaſſe ſewed vp round and marled and coated ouer as afore is taught, boring a hole therein of an inch deep, and priming the ſame full of bruiſed powder: this ball will burn in the water whenſoeuer you would vſe the ſame, but is not of ſuch force as the ball filled with other mixture. You may make balls of this receit to ſhoot out of a Morter peece, boring thorow the ſame two holes, the one croſsing the other, or boring three holes in the ſame, into the center or mids of the ball, as the draught L ſheweth.

It is good eyther for ſeruice on ſea to burne the ſailes of ſhipps, or on the land for diſordering men in battell ray being neere, or for diuers other militarie ſeruices, to haue certaine ſhort muskets of an inch or very neere an inch bore, out of which you may ſhoot eyther chained bullets, or halfe a ſcore piſtoll bullets, or halfe a dozen harquebuz bullets at one ſhot; or you may ſhoot out of the ſame fire-arrowes made with ſtrong ſhafts fethered with horne, or with common feathers, glewed & bound on with threed: when you are to ſhoot a fire-arrow out of any of theſe peeces, you muſt not giue the peece her full loading of powder, but rather $\frac{2}{3}$ parts thereof, and then put in a cloſe wad after the powder, and put in the arrow cloſe to the ſaid wadde, firing the ſame at the other end without the mouth of the peece, as you ſee the

draught

draught: which being well fired, you may discharge the same at your pleasure. The string made fast to the end of the fire-worke, is to keepe the arrow streight in his passage, being shot eyther with or against the winde.

For the like seruice aforenamed, it is good to haue certaine strong bowes to shoot fierie shafts, something stronger and longer than ordinarie shafts: for making the fire-worke fast to them, the which being fired and discharged out of the bow by a skilfull Archer, hauing a strong arme, will doe excellent good seruice for diuers occasions, as by the draught hereunder you may see.

I might here adioyne varietie of ſeruiceable fire-works, as alſo ſhew many deuices of pleaſant fire-works to be vſed in triumphs before great perſonages; but to the wiſe theſe may ſuffice, who by experimenting theſe may eaſily performe the other.

Here followeth the making and vſe of the Geometricall Inſtrument, called the Gvnners Quadrant.

THe Quadrant geometricall is the moſt common and eſpeciall Inſtrument vſed amongſt the Profeſſors of the art of Gunnerie, moſt eaſie to vnderſtand of the vnlearned, both for bringing their peece leuell with anie marke they are to ſhoot at, as alſo to ſhoot at any degree of the randon: the effects whereof I haue not ſeene ſet out in any booke of Gunnery, & therefore haue thought good to ſhew ſome notable practiſes by the ſaid Inſtrument to bee performed, the making and vſe whereof briefly followeth.

To make a Geometricall Quadrant eyther of mettall or of fine ſmooth wood, draw foure equall ſleight lines, that may cut each other ſquare-wiſe, of ſeuen or eight inches length or more, for the larger the leſſer error, as you may ſee in the figure AB, BC, CD, DA, following. And from the center A, draw a ſlope line to C, called the hipothemiſall line, and of ſome a diametrall line, vpon which if the plum line fall vpon the center A, looking through the ſights E, F, beholding the extreame or higheſt part of any altitude, the diſtance from the middle part of your foote to the baſe thereof, adding thereto the iuſt height from your eye, is

the iuſt height of the ſaid altitude: but if the plum-line fall on the line A B. then any marke that you view through the viſuall ſights E F, is of equall height or leuell with your eye. Or putting the rule into the concaue of the peece, ſo that the threed fall on the line A B, then that peece lieth point blanke, or in a ſtreight line with any marke you are to ſhoot at: or if the plum-line fal on the line A D, the thing you behold is direct vpright; then opening your compaſſe the iuſt length of any one of theſe ſquire lines, ſetting one foote in the center A, with the other foote draw an arke or circumference from the angle D to B, which arke ſhall be the iuſt $\frac{1}{4}$ part of the circumference of a circle, and is called a Quadrant, the which is to bee diuided into ninetie equall diuiſions, which is called degrees: which may eaſily be done, by diuiding the arke into three equall portions, and euery of them into three, ſo haue you nine equall parts, ſo that diuiding each of them into two parts makes 18. equall parts, and euery of thoſe into fiue equall parts, will make iuſt ninetie equall diuiſions or degrees: ſo is your Quadrant finiſhed.

The ſcale which is the ſquire lines B C, and C D, may be diuided into 12. 60. yea 100. or 1000. diuiſions, the more the better, for the vſe of ſhadowes, lengths, heights, &c. Where you muſt remember, that the ſide C D, is called the right ſhadow, and ſheweth how to meaſure all heights within the length thereof, but the ſide B C, is of contrary ſhadow, which ſerueth to meaſure all heights without the length thereof, the vſe whereof followeth.

The rule to which the Quadrant is artificially ioyned would bee two foote in length, diuided in equall in-

ches and parts with a hollow ſlit in the midſt, vpon which would bee placed a fine plate with a little round hole in the middle thereof, to view any marke ſetting the rule vpright at the breech of the peece: the ſaid plate would bee made to moue vp or downe at pleaſure, by which you may know what length or what inches and parts any peece requireth to reach any marke. The viſuall ſights placed on the edge of the rule would not bee aboue two or three inches from the ends thereof, and the rule would bee of weight to counterpoize the quadrant, ſo that when the rule is put vnto the concaue of the peece, the Quadrants weight doe not raiſe the ſame.

Before you beginne to meaſure the length or height of any altitude, or to know whether any mark you are to ſhoot at be higher or lower than your platforme, or the cilinder of your peece, it behoooueth you firſt to ſee whether the baſe or loweſt part of the ſaid mark or altitude bee aboue or vnder point blanke; the which you may know by viewing the ſame through the ſights on the rule, letting the threed fall at libertie on the degrees of the Quadrant. And if the plum-line fall on the line of leuell, then the marke is of equal height with your eye; if the threed fall towards you, the marke is aboue point blanke; if from the line of leuel, it is vnder point blanke. And for the more true and perfect working of the concluſions following, it is good to make a little hollow skrew in the middle of the hipothemiſall line, and to haue a ſtaffe or gunners Iauelin to erect perpendicularly with a little skrew plate of yron on the end at the ſide thereof, into which turning a skrewed naile through the hole ſo made in the Quadrant, you may make the

ſame

ſame vnmoueable, ſo as you may liſt the ſame vp or down to behold any marke at pleaſure: for no man can hold his hand ſo preciſely but it will ſhake and moue, and ſo cauſe the threed to erre a little.

How you may by your Geometricall Quadrant meaſure the height of any wall, Tower, Steple, Tree, or any altitude approachable.

GO towards the ſame vntil by ſuppoſition you think you are near about the length of the height of the ſame, and then ſetting the Quadrant to your eye, looking through the viſuall ſights, beholding the extreame or higheſt part of the altitude, goe to or from the ſame vntill the threed and plummet cut or fall vpon the part twelue of right ſhadow; then meaſuring how farre it is from the middle part of your foot to the baſe of the ſaid altitude, thereunto adding the height from your eye to the ground, you haue the iuſt height of that altitude.

The ſame concluſion is to bee wrought by the ſhadow or beam of the Sun, in turning the left ſide of your Quadrant to the Sunne, ſo as his beames may pierce through the viſuall ſights of the plummet falling on the part twelue, the diſtance from the furtheſt point of that ſhadow to the baſe of the altitude is the iuſt height of the ſame, being an vpright altitude.

How you may diuers waies finde out any vpright height within the length thereof both by the ſhadow and without ſhadow.

IF the ground be plaine and that you may goe ſo neare

to the baſe of the altitude, that the plum-line may fall on the part one of right ſhadow; then meaſuring the diſtance from the midſt of your foote to the baſe thereof, multiplying that meaſure by twelue, and adding thereto the height from your eye to the ground, you haue the true height of that altitude: or letting the Sunne beame pierce through the viſuall ſights of the plum-line, falling at libertie on the part one of right ſhadow, meaſuring and multiplying that meaſure by twelue, and diuiding by the parts whereon the plum-line hangs, the quotient wil tel you the true height of the ſame altitude: for this is a generall rule, that looke what part of right ſhadow is cut by the threed or plum-line, the altitude or vpright height to bee meaſured is more than that ſhadow, by ſuch proportion as twelue exceedeth the part or diuiſion of the skale where the threed or plum-line was found.

If the threed bee found to fall on the part 2. of right ſhadow, meaſure the diſtance from the midſt of your foote to the baſe of the altitude, ſixe times that meaſure is the height of the ſame, adding the height from the eye to the ground, for the part 2. is contained in 12. (the diuiſions of the ſcale) ſix times; or what part ſoeuer it fal on of right ſhadow, look how oft that part is contained in 12. ſo many times as that meaſure is from the midſt of your foote to the baſe, euer adding the height from your eye, is the true height of the thing you meaſure. Or in briefe, if the plum-line fall on the part 3. working as is ſaid, foure times that meaſure is the height of the altitude.

Or if it fall on the part 4. then three times; if on the part 5. two times $\frac{2}{5}$ parts of the ſhadow is the height: if

on

on the part 6, 2 times: if on the part 7, once & $\frac{1}{7}$: if on the part 8, once and $\frac{1}{2}$: if on the part 9, once $\frac{1}{9}$: if on the part 10, once and $\frac{1}{9}$: if on the part 11, once $\frac{1}{11}$ part of the shadow. All these mensurations be to be wrought within the length of the altitude.

In measuring by the points of contrary shadow, which sheweth to measure all altitudes without the length therof, you must multiply the length of the shadow by the point or diuision of the scale wheron the threed falleth, diuiding the result by 12, the quotient will shew you the true height of the altitude.

Or without shadow, goe so neare to the same that you imagine you are neare within the length thereof, lifting vp the Quadrant orderly, going to or from the same, till through the sights you espie the top or highest part of the altitude, the threed falling on the part 12; standing vpright with your body, and at the midst of your foote make a marke, then goe directly backeward from the same, till through the visuall sights you espie the highest part againe, the threed falling on the part 6 of contrary shadow; and at the midst of your foot make another marke, the distance between those two markes adioyning thereto the height from your eye to the ground, is the true height of the altitude: and your furthest station is twice the length of the height of the altitude, wanting the height from your eye to the ground, which you must euer adde to the worke.

Another way.

If at the first station the threed fall on the part 6 of contrarie shadow, & at the second station on the part 4, the distance betweene those two markes is the height,

adding as before, and the furtheſt ſtation is three times the length of the altitude you meaſure from the baſe therof, the ground being plaine.

Another way.

If at the firſt ſtation the threed fall on the part 4, of contrary ſhadow, and at the ſecond on the part 3, then the diſtance betweene your two ſtandings is the height defired, adding as afore, and the furtheſt ſtation is diſtant from the baſe of the altitude foure times the length or height thereof.

Another way.

If at the firſt ſtation the threed fall on the part 3, and at the next the part 2, then the diſtance betweene thoſe two ſtandings is twice as much as the length of the altitude, excepting the height from your eie to the ground, and your furtheſt ſtation ſhall be from the baſe of the altitude ſixe times the height thereof.

Another way.

If at the firſt your threed fall on the part 2 of contrarie ſhadow, and at the ſecond on the part one, the ſpace between the 2 ſtandings, ſhall be ſixe time the length or height of the altitude, or the 6 part of that meaſure ſhall be the height thereof; and your furtheſt ſtation ſhall be diſtant from the baſe thereof, twelue times the height thereof.

And note that if the ſcale were diuided vnto 60, 100, or 1000 diuiſions, by ſo much further from the thing to be meaſured might you find out the height thereof.

How you may likewiſe by the parts of right ſhadow in the ſcale by the ayde of two places finde out any approachable height.

PLace your Quadrant handſomly to your eye, til beholding the extream of the altitude through the viſuall ſights, your threed falling on the part 12, and at the middle of your foot make a marke, and going nearer to the baſe of the altitude directly forward, beholding the extreame or higheſt part of the altitude, the plummet cutting the part 6, at the middle of your foote make another marke, double that ſpace, and thereto adioyne the height from your eye to your foote, the ſumme is the true height of the altitude.

Another way.

Lift vp your Quadrant as afore, the plummet cutting the part 12, and going nearer till it cut the part 8, marking the middle of both your ſtandings, meaſure that diſtance, and triple that meaſure, and thereto adde the height from your eye, you haue the height.

Another way.

Let the threed cut the part 12 and 9, marking the middle of both your ſtandings, meaſure the diſtance, quatriple that meaſure, and adde the height from your eye, you haue the height.

Another way.

If at the firſt ſtation the threed cut the part 12, and at the next ſtation the part 10, fixe times the diſtance of the 2 ſtation is the height, adding as aforeſaid.

Or

Or if at the first it fall on the part 12, and at the second on the part 1, then 12 times the distance of the 2 stations is the height desired, adding the height from your eie to the ground.

A generall rule how you may by a Gunners Quadrant measure all heights by *Arithmeticall skill.*

NOte what point or diuision of the skale the threed falleth on, your eye beholding through the visual sights of your rule the iust top or extreame part of the altitude, if the threed fall on the parts of right shadow, then multiply the distance from the midle of your foot to the base by 12, and diuide by the parts of the skale wherein the threed fell, adding thereto the height from your eye to the ground, you haue the height. But if the threed fall on the parts of contrarie shadow, then multiply the distance from the middle of your foote to the base by those parts, and diuide by 12, and to the quotient adde the height from your eie to the ground, you haue the altitude likewise.

Example.

SVppose the plum-line cut the part 5 of contrary shadow, the distance from the middle of your foote to the base of the altitude 110 foot, that multiplyed by 5, is 550 foote, the which diuided by 12, yeeldes in the quotient 45 foot $\frac{5}{6}$, to which adde fiue foote, the height from your eye to your foote, the summe is fiftie foot $\frac{5}{6}$, the true height of that measure.

Or suppose the threed fall on the part 6 of right shadow,

dow, the distance from the middle of your standing to the base of the Altitude 24 foote, which multiplied by 12 makes 288, diuided by 6, the quotient is 48 foot, to which fiue foote added, the supposed height from your eye to the ground is 53 foote, the height of that altitude.

Note in euery working, whether the ground at your standing be leuell or not with the base of the altitude, if it be either higher or lower than the base, the plum-line falling on the line of leuell, will tell you what part of the base is leuell with your eye.

A generall rule to measure the length or distance of the parts or part of any *Altitude.*

YOu must first finde out the height of either part of the thing you would measure, by the rules aforesaid, in taking the length or height of the top and base of the same, abating the lesse out of the more, the remaine is your desire. Or setting vp perpendicularly a Gunners lauelin, Halbard or staffe, diuided into equall parts, a little within the length of the heigth of the altitude you would measure, mouing your selfe from the same backwards, either lying on your back, or stooping your eye low towards the ground, till you can espie the extreame tops or ends of the altitude and staffe in a streight line from your eie, and then not mouing your eie, view the lowest part of the same thing you would measure, and suppose the visuall line cut or passe by the third part or diuision of the staffe, which imagine to bee diuided into 8 equall parts, or 8 foot the length therof;

and that the distance from your eye to the base of the staffe is eighteene foote, and the distance from your eie to the base of the altitude is 120 foot, frame the rule of 3. saying, if eighteene foot the space from your eye to the staffe yeelde 120, foote which is the distance to the base of the altitude, what will 3 foote? multiply 120 by 3, ariseth 360, diuide by 18, the quotient is 20 foote, the height of that part of the altitude you desire to measure.

A rule how by the degrees of the Quadrant by knowinga part or portion of the base or lowest part of any Altitude, to find out the height of the same.

GOe so neare to the thing whose height you would measure, setting the rule to your eie, so as the plum line falling on the line of leuell, may point equall with the base of the altitude, or else note some marke of the altitudes base, where your visuall sight points at the threed falling on the line of leuell; then raise the quadrant higher, so standing still as the threed may fall on the first degree thereof, and looking through the sights, marke where the visuall line points at, the distance betweene those two markes is to be measured. And lastly, lifting vp your Quadrant, beholding the top thereof through the sights, marke vpon what degree the threed falleth: and so by knowing the distance and height of the first degree, you may easily by the golden rule find out the height of the altitude. Example. Say or suppose the threed falleth on the sixt degree of the quadrant: when you behold the top thereof through the visuall sights, and the knowne distance of one degree is 8 foote, then

say

ſay, if on degree yeeld 8 foot, what ſixe? you ſhal haue 48 foote, the true height thereof.

How you may by a Gunners Iauelin or Halbard, or any ſtraight ſtaffe, finde out *any approchable height by the ſhadow.*

SVppoſe the Gunners Iauelin be 8 foote in length, ſet the ſame vp perpendicularly, and meaſure the length of the ſhadow the ſame caſts, which meaſure ſuppoſe to be twelue foot. Then meaſure the length of the altitudes ſhadow, which ſuppoſe to be 60 foote. Then framing the rule of Proportion, ſaying, if 12 foote knowne ſhadow yeeld 8 foote height, what 60? and ſo multiplying 60 by 8, and diuiding by 12, the quotient is 40, ſhewing the height of the altitude is iuſt 40 foot in height; the like rule is in *Vegetius*.

Another way without ſhadow by any ſtreight thing perpendicularly erected to *finde out the height of any approchable Altitude.*

SEt vp a ſtaffe or gunners Iauelin perpendicularly as afore, ſomewhat within the length of the altitude, going from the ſame, and lying on your backe, moue your ſelfe to or from the ſame, till you can eſpie the very end of the Iauelin, and the top of the marke in a ſtreight line from your eye: ſuppoſe the diſtance from your eye to the ſtaffe 12 foote, and the diſtance from your eye to the baſe of the altitude 60 foote, and the height of the Iauelin 8 foot; ſay, if twelue foot the ſpace

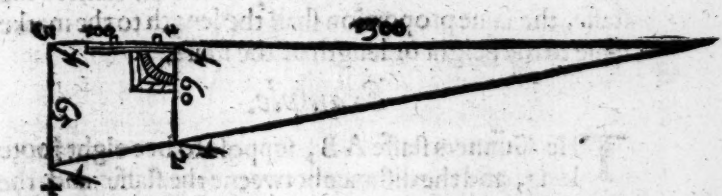
from your eye to the ſtaffe yeeld 8 foot height, what wil 60 foot (the diſtance from your eie to the baſe of the altitude?) Multiply and diuide, your quotient is 40, as afore, ſhewing the altitude of the thing to be meaſured. The like rule is in Maſter *Digs* his Geometricall booke called *Pantometria*; who ſheweth alſo in the ſame, how by any two ſtaues of equall length ioyned in a right angle ſquirewiſe, you may find any altitude, by ſetting the one end thereof to your eye, going to or from the thing to be meaſured, vntill you can by the points or ends of the other ſtaffe with one eye view both the baſe and top of the altitude, making a mark at the midſt of your foot, the diſtance from that mark to the baſe is the iuſt height of the thing you ſeek to meaſure.

Many mo waies there be to finde out heights, both by the Quadrant, ſquire, triangle, glaſſe, ſtaffe, &c. which I let paſſe: the vnexperienced by theſe few eaſie concluſions may the ſooner attaine the reſt.

How you may by the helpe of the Quadrant from any plaine platforme know the diſtance therefrom to any marke you are to ſhoote at.

LAy your Quadrant flat vpon ſome ſtoole, or take a ſhort ſtaffe with a skrew in the end thereof, erecting the ſame perpendicularly, and put the Quadrant vpon the ſame skrew, then by the edge of the rule turning the ſame to the marke whoſe diſtance you would meaſure, or through the viſuall ſights on the rule eſpie the marke, and at your ſtanding ſet vp a Gunners ſtaffe or Iauelin, then turning your body croſſe the ſame, not altering

the rule and Quadrant by the line of leuell, on the edge of the Quadrant espie some other marke athwart the first, and set vp the second staffe, the distance whereof suppose to be 60 foote; then comming to the first station where the quadrant is placed, viewing by the edge of the rule through the visuall sights, some other mark in a streight line back from your first station, whose distance suppose 100 feete, and there erect vp the 3 staffe, and so the first and the third staffe will bee in a streight line with the mark, then with a squire or remouing the quadrant to the 3 station, turning the right angle or line of leuell ouerthwart towards the second station, so as the visuall line may bee parallell to the line that crosseth from the first station to the second, there set vp the 4 staffe, so as the visuall line passing from the same, and running by the second staffe, may crosse the marke or end in a point there with the first visuall line, the distance betweene these two last stations suppose 65 feet, the staues thus placed in order abade 60 feete, the distance betweene the first and second station from 65 the distance between the 3 and 4 staues, the remaine is 5 for your deuisor; then multiply the said 65 by 100, the



distance from the first to the 3, ariseth 6500, the which diuided by 5, the quotient is 1300 feete, the distance

from the firſt ſtaffe, to the marke. Behold the figure before, where the cipher O, repreſents the marke, the vnite 1. your firſt ſtaffe or ſtation, the figure 2 the ſecond ſtaffe, the figure 3 the third ſtaffe, and the figure 4 the fourth ſtaffe.

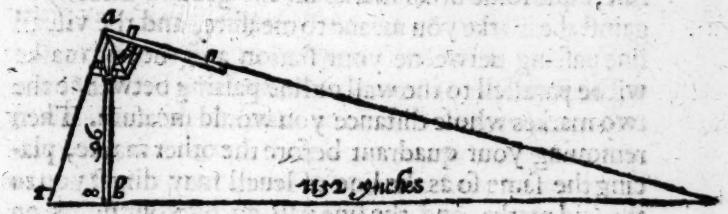
How you may another way by the Quadrant and your Gunners ſtaffe diuided into euen portions, tell the diſtance to any marke neare hand that you are to ſhoote at.

SEt the angle of your Quadrant vpon the very point or top of your ſtaffe, the ſaid ſtaffe perpendicularly erected, and through the ſights on your ruler eſpie the marke whoſe diſtance you deſire to meaſure, letting a long threed or ſmall line fal to the ground from the center of the Quadrant whereon the plum-line hangs, which threed muſt be drawne along the line of leuell or edge of the Quadrant to the ground, marking where the threed points at on the ground, beholding the mark through the viſuall ſights in the rule of the Quadrant: and looke what proportion that part of ground between the ſtaffe and where the threed pointed at, hath to the ſtaffe, the ſame proportion ſhall the length to the marke haue to the height or length of the ſtaffe.

Example.

THe Gunners ſtaffe A B, ſuppoſe to bee eight foote long, and the diſtance betweene the ſtaffe and the ground where the threed points you to (being the ſpace C B) is but 8 inches, therefore looke what proportion C B beareth to the length of the ſtaffe (which reduced into

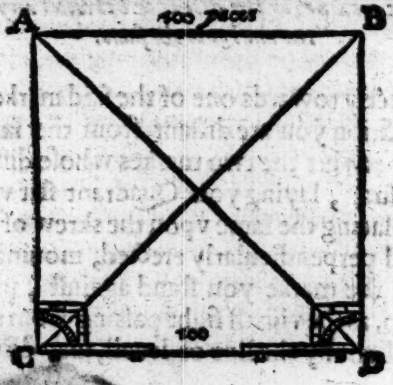
into inches will be 96 inches) the ſame proportion ſhall the length to the marke D haue to the ſtaffe, which by the golden rule is thus found. If 8 inches yeeld 96 inches, what will 96 inches? multiply 96 by 96, ariſeth 9216 inches, diuided by 8, yeeldes in the quotient 1152 inches, the diſtance from the ſtaffe to the marke: and note that the higher the pole or ſtaffe is, the further may you meaſure by this rule; behold the figure.



How you may by a Gunners Quadrant readily meaſure the length of anie wall or *curtaine, or the diſtance betwixt any two markes in the ſame.*

GO directly towards one of the ſaid markes, that by ſuppoſition you are diſtant from the ſame about the length betwixt the two markes whoſe diſtance you would meaſure, laying your Quadrant flat vpon ſome ſtoole, or placing the ſame vpon the skrew of the ſtaffe aforenamed perpendicularly erected, mouing the ſame to or from the marke you ſtand againſt, placing the Quadrant ſo, as the viſuall ſight paſsing from the center of the Quadrant by the line of leuell, may direct you to the

the ſaid mark, & the viſuall line paſsing from the center of the Quadrant by the 12 point or diuiſion of the ſcale which is the hipothemiſal line, may direct you to the other marke; and then the length of your ſtanding to the marke which the line of leuell directs you to, is from the ſame iuſt the diſtance betweene the 2 markes you meane to meaſure. Then looking athwart by the other edge of the Quadrant, or through the ſights on your rule, eſpie ſome other marke on the ground directly againſt the marke you meane to meaſure, and the viſuall line paſsing betweene your ſtation and the ſaid marke wil be parallell to the wall or line paſsing betweene the two markes whoſe diſtance you would meaſure. Then remouing your quadrant before the other marke, placing the ſame ſo as the line of leuell may direct you to the ſaid marke, and the line paſsing by your ſights on your ruler may direct you to your firſt ſtation, the diſtance betwixt your two ſtations being meaſured, is the iuſt ſpace betwixt the two markes you ſeeke to meaſure, as the demonſtration hereunder ſheweth, where the



line

line A B, sheweth the length or distance I would measure supposed to be 100 paces, and the like number is found both in the line C D, as also in the lines C A and D B, which proues the worke to be truely wrought.

How you may by the former conclusion at one station measure the distance to *both the former markes.*

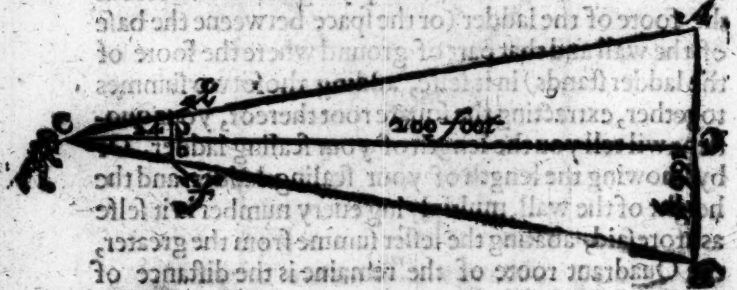
THe distance from your standing C, to the marke A, which the line of leuell directs you to, is iust 100 paces, that summe squared, makes 1000 paces. The like number of paces is found in the line A B, being multiplied in it selfe: these two summes beeing ioyned together, makes 20000 paces, the quadrant root thereof is 141 paces and almost $\frac{1}{2}$, shewing the true distance from you standing to your furthest marke B.

The like order you must obserue to know the iust length of any scaling ladder, to scale the wall of any castle, tower, or towne besieged, in taking the height of the said wall with your quadrant, or otherwise as afore hath beene taught, multiplying that knowne measure in it selfe: and likewise multiplying the distance from the foote of the ladder (or the space betweene the base of the wall and that part of ground where the foote of the ladder stands) in it selfe, adding those two summes together, extracting the square root thereof, your quotient wil tell you the length of your scaling ladder. Or by knowing the length of your scaling ladder and the height of the wall, multiplying euery number in it selfe as aforesaid, abating the lesser summe from the greater, the Quadrant roote of the remaine is the distance of

the ground from the foote of the ladder to the baſe of the wall. Or by knowing the length of the ſcaling ladder and the length of the ground from the foote of the ladder to the baſe of the wall, you may find out the height of the wall, in multiplying each number in it ſelfe, abating the leſſer ſumme out of the greater, extracting the ſquare roote of the remaine, the quotient will anſwer your demand, as is demonſtrated and proued in the 47 propoſition of the firſt booke of *Euclids Elements*.

How you may by the ayde of two ſtaues or Gunners Iauelins perpendicularly erected, *by knowing the diſtance from your ſtanding to the middle part betwixt any two markes, meaſure the diſtance betweene the ſaid markes.*

ADmit the line A B is the 2 markes whoſe diſtance I would meaſure, and the line C D is the knowne meaſure to the middle part betwixt the ſaid markes, which I ſuppoſe to be 200 feete, erect vp the two ſtaues E F, ſo as the viſuall line from your eye at C, paſsing by the ſtaues, may point directly to the ſaid markes A B.



The distance betwixt the two staues suppose to bee 20 feete, and the distance from your eye to the staues 24 feet; frame the rule of 3, saying, if 24 foot (being the distance from your eye to the staues) yeeld 20 foot (which is the space betwixt either staffe) what will 200 foote (which is the length of the line from C to D:) Multiply 200 by 20, ariseth 4000, diuide by 24, the quotient is 166 feete $\frac{8}{12}$, the true distance betwixt the two markes A B which you seeke to measure.

How you may by the diuisions of the scale of your quadrant, by knowing the distance to any tower, steeple, tree, or other mark, not farre distant, know how much the same is higher or lower than your standing.

THe distance known, note by what point of the scale of your quadrant the index or threed fals on, in viewing the same marke through the sights on your ruler, by which point or diuision you must diuide 12, (the diuisions of your scale). and note what comes in your quotient, by which quotient number diuide the distance from your standing to the base of the marke, your new quotient number will tell you how much the top of the marke or altitude is higher than your eye.

Example.

THe distance from my standing to the base of the altitude suppose to be 200 feete, the plumline falling on the part 6 of contrarie shadow, I diuide 12 by 6, the quotient is 2, by which quotient number I diuide 200 feet (the space betwixt my standing and the marke, and so

so I find 100 in my new quotient: so I affirm the top of the marke was 100 foot higher than my eye. The like is to be done for descents in turning the contrary angle of the quadrant to your eye.

Note that to take the distance betweene any 2 markes with the quadrant, the markes beeing not farre asunder, you must obserue the like order you doe in taking heights, sauing that in measuring heights the quadrant must euer hang so as the plummet and threed hauing libertie to moue to and fro, may euer hang perpendicularly: and to take distances the quadrant must euer lye flat, so as the same doe euer make a square angle against the markes whose distances you would measure: in working whereof an *Athilleda*, index, or pointer (as some terme it) placed in the center or angle of the quadrant hauing two sights thereon, will direct you much better to the markes than the threed. Many other conclusions are to be found out, and wrought by this instrument: to the ingenious these few may suffice.

FINIS.